THE MEANING

OF

ORGANIC EVOLUTION

BY

RALPH V. CHAMBERLIN

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PROVO, UTAH
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LeGrand Woolley

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PREFACE

No scientific law has ever been more widely misunderstood as to its content, or more thoroughly and persistently misapprehended as to its significance than has that of Evolution or Organic Descent. The problems of life are throughout largely problems of adjustment; and it is only natural, therefore, for people to suspect, fear or oppose anything strange or not mentally comprehended, inasmuch as their lack of experience and knowledge with reference to it leaves them to grope more or less in uncertainty. Hence, since the minds of most persons in the ordinary walks of life are but meagerly provided with the ideas and materials upon which the theory is based and as a consequence form the conception, if at all, with difficulty and but imperfectly, we can readily understand why Evolution, or what has passed for it, has met with such prejudice and opposition. Misunderstanding on the part of church members, in particular, has been very unfortunate; for the consequent opposition, prolonged and often bitter, has in reality been without rational justification and has resulted in much harm through hampering both intellectual and religious progress. The issues of this conflict, now so far a matter of history, in fact, attest the truth and give specific illustration of the following proposition formulated many years ago by Andrew D. White: *"In all modern history interference with science in the supposed interest of religion, no matter how conscientious such interference may have been, has resulted in the direst evils both to religion and science, and invariably; and, on the other hand, all untrammeled scientific investigation, no matter how dangerous to religion some of its stages may have seemed for the time to be, has invariably resulted in the highest good both of religion and of science."*

The following pages are written in non-technical terms for the general reader, their purpose being briefly to explain certain aspects of Organic Descent about which misunderstanding and misapprehension seem particularly to cling. 1. Few people correctly know the history of the evolution idea, many supposing it to date no farther back than Darwin

and sometimes even lightly speaking of it as an incidental or passing scientific "fad." The first section of this little volume is devoted to showing that the idea, on the contrary, is a very old one, and that the Evolution theory in its modern form is the substantial result of a long and consistent development and the culmination of many lines of scientific progress running back into the past and showing again that "truth is the daughter of time." 2. Persistant and fundamental errors as to what the processes formulated under Evolution really are occur widely. The second chapter is intended to explain what these processes in their essentials really are and specially to point out some things that the theory does not embrace. It is distressing to find people even yet discussing and opposing things that never have been part of the scientific theory but which have, in the main, emanated from the reviews of hasty and shallow critics, things which all to often, in fact, are wholly incompatible with the real law. 3. In the third section, the basis of the Theory of Descent in Biology is considered in brief, the kinds of evidence that has convinced the entire world of biologists that Evolution must be received as demonstrated being concisely outlined. For, while biologists are divided among themselves as to the controlling factors, all are united as assuming as beyond question the actuality of the process. It is mere folly and ignorance to speak of evolutionists as constituting a particular school or "cult" of scientists. *"The day is past when evolution might be regarded as a school of thought. We might as well speak of a gravitationist as of an evolutionist."* 4. The final chapter is devoted to a consideration of the function of science and of the real nature and meaning of scientific law, matters wholly misunderstood by most people. The work of science is shown to be the accurate registration and identifiable description of phenomena in their spatial and temporal relations, through a knowledge of which the prediction of occurrences becomes possible and thereby our control over the course of events in Nature continually augmented. Science confines itself to explaining more and more fully *how* things come about in the Universe; it always is, and in the very nature of things must remain, silent as to the *why*. The primary or actual cause under-

lying the appearance remains hidden, an eternal mystery. Evolution as such a descriptive formulation of a process cannot be valid in causation; and, hence, it leaves the question of Creator and of a guiding and controlling Intelligence untouched. Evolution is seen to offer a higher and more forceful teleology than the outgrown hypothesis it has displaced; and, through it, the general grounds of the rational theist are strengthened and ennobled.

We cannot let go of the past nor the past of us. We are out of the past and must live upon foundations there laid. The problem of intelligent growth and progress in life is, with ripening time, to replace what is outgrown and noxious in these foundations with the strong elements of the new in such a way as to keep intact the framework of the high ideas and ideals won and proved in the past struggles of the race and coming to us as a priceless heritage. Our problem is one of assimilation, not one of destruction.

R. V. C.

Provo, Utah,
March 5, 1911.

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PHASES IN THE HISTORY OF THE EVOLUTION IDEA.

Careless seems the great avenger; history's pages but record
One death grapple in the darkness 'twixt old systems and the Word.
Truth forever on the scaffold—wrong forever on the throne;
But the scaffold sways the future, and behind the dim unknown,
Standeth God within the shadow keeping watch above his own.—Lowell.

The present intellectual heritage of the human race is the result of a growth that has been slow and painful. Had the leaders in thought and the search for truth in past times always been free from the strong restraining influences of society, this growth, in the very nature of things, must still have been very slow; it has been inestimably slower because of the impediments which society ever throws in the path of its own progress. John Wesley once truly wrote: "In process of time many important discoveries have been made which have been gradually assented to as prejudice could give place; allowing that it takes a century

to make a discovery, it takes another century to remove a prejudice. The modest efforts of reason are too feeble to shake the foundations of error." To dislodge ideas after they have once been widely accepted has always been difficult. "The progress of science must be slow; see what a turmoil a little advance can make" (Franklin).

The earliest conclusions in every field have had to be revised and re-revised many times before the present degree of correspondence to the realities could be reached. Each revision has taken time, and, commonly, a severe and often bitter struggle. To depart far from the average of the society of which one is a part has always meant to stand alone, to be misunderstood by contemporaries and, all too often, to be reviled and persecuted. The opinion of this society is, in fact, with most, a more powerful check on thought, utterance and general personal conduct than all fear of civil law and future punishment combined. People almost instinctively fall into the ways of thinking, of judging by the standards and with the assumptions, prevalent with those among whom they live. Those able to leave the beaten paths and to think thoughts in any way essentially new are rare; while those who have added to this ability the elements of character leading them actually to reach and to express such thoughts, in a way sooner or later to enter the current of life as new forces, are the truly great, scattered sparsely through

the centuries of the past.

A study of the origin and development of prevalent beliefs and theories concerning any problem of interest and importance to men is always instructive and conducive to tolerance, breadth and truthfulness in judgment. And, hence, at this time, when the whole civilized world has so recently been uniting in celebrating the hundredth anniversary of the birth of Charles Darwin and its intellectual princes paying tribute to his work and worth, it seems especially desirable to review important phases in the history of thought concerning the problem and doctrine with which his name is most prominently connected—that of organic evolution. The purpose in the present section is briefly to present such a review and in some measure to make clear the actual status of the doctrine in the scientific world today.

We see about us a countless number of individual plants and animals. Some attention reveals, furthermore, that these individuals may be grouped in a more limited number of series in each of which the forms are closely similar, so similar that we might readily suppose them to have common parentage. Such series of organisms, popularly spoken of under the indefinite term kinds, are more technically designated as species. Of such species of living things there are several millions now living; while in the past a vastly greater number have lived and gone their ways to extinction.

The theory of evolution in biology, broadly speaking, is that according to which all these varied species of organisms, that exist or have existed, have come into being by descent with divergence and modification from one or from but few original types. The theory stands in opposition to that according to which each species has been brought into being separately and independently of all the others. Both theories of creation demand a cause, the first certainly as much as the second. They are the answers that have been given to the question, "By what method?" which is one to which Science may properly address itself. The question, "By whom?" belongs to Theology.

Irrespective of any question as to validity, it must be frankly admitted by all that the doctrine of evolution, since it first became widely accepted among scientific men fifty years ago, has profoundly modified the method of human thought in every field of knowledge. To eliminte it and the results due directly to it now would mean to unravel the whole fabric of the natural and social sciences and, in the opinion of the leaders in these sciences, to take away the richest fruits of the intellectual progress of the last century. "Whether planets, or mountains, or mollusks, or subjunctive modes, or tribal confederacies be the things studied, the scholars who have studied them most fruitfully were those who have studied them as phases

of development. Their work has directed the current of thought" (John Fiske).

Notwithstanding this profundly significant position of the theory, no other has been more widely and egregiously misunderstood as to its real nature and bearings, and more bitterly and with so little reason opposed. The minds of most men are but poorly provided with the facts and ideas upon which the theory is based; and, as a result, they form the conception only with the greatest difficulty and, at best, very imperfectly. Along with this there has been an amazing persistence of grave misapprehensions of the doctrine set afloat in the past in hasty and shallow reviews and in impulsive and ill-considered diatribes. Hence it comes that what passes for the doctrine in the minds of many is but a composite of such misapprehensions and a varying number of elements truly part of it.

The modern doctrine of evolution is the result of a development traceable back through the centuries to the very dawn of history, crude and obscure and mixed with much error though the idea was at the beginning. All we could expect to find among the primitive peoples of antiquity would be the germ of the thought and an attitude of mind or point of view suggestive in some degree of that demanded by the elaborated theory. Any notion or belief, however partial, as to a creation through a growth process, or through the operation of secondary or intermediate

causes, must be looked upon as pertinent and tributary. Such a notion existed among the earliest Egyptians. It was but natural that these people who every year saw the rich Nile sediment bring forth with seeming spontaneity swarms of "creeping things" should mistakenly think that these creatures actually sprung from the mud itself and should believe that they took form as the result of a productive power imparted to the earth by the creating divinity in the beginning. Similar ideas of the origin of living things in part or wholly through a growth process, doubtless based primarily upon similar observations and elaborated variously in accordance with the different cultures, influenced more or less strongly most ancient philosophies and theologies.

The deciphering of the inscriptions recovered from the Chaldeo-Babylonian ruins and forming probably the most ancient human documents known, has given us, among other things, their several accounts of creation. From this record it is clear that the Babylonians believed space was filled, in the beginning, with a continuous mass of water. According to the main account, the earth took shape in the midst of this watery chaos as a flat body, following the divine command. Next appeared a solid vault or firmament arching above the earth and thus keeping back the water from the earth and separating the waters above from the waters beneath. Then only could dry land appear.

After its appearance, the divine fiat again issued and the waters of the earth brought forth fish and other sea-animals, and the land produced the land forms and plants. The whole creation is thus represented largely as a growth or crude evolution process initiated by the divine power or word.

The main features of the Babylonian account of creation seem to have passed to the Phœnicians, Assyrians, Hebrews, and other neighboring peoples. Through Phœnicia they passed to the early Greeks, the fertile genius of whose philosophers took hold especially of the evolution idea and elaborated and extended it in a way at times strongly suggestive of modern conceptions. Anaximander shows clearly the influence of the Babylonian story. He was the first to hint that man must have originated from lower forms. Crude evolution theories or suggestions toward such are worked out and presented in the teachings of Anaxagoras, Heraclitus, Thales, Pythagoras and Empedocles. Heraclitus was particularly impressed with the constant and orderly changes occurring in the universe and accordingly saw in movement or change—in an evolution, the universal law or cosmic process. Empedocles had a conception of the gradual development on the earth of higher and higher forms of life, the earliest being rude and imperfect, and a "struggle for existence" ensuing in which the more monstrous and

deficient were gradually eliminated. He thus conceived of an evolution definitely regulated by law.

The evolution theory among the Greeks reached its highest and most refined development in the master mind of Aristotle. Aristotle was more than a speculator; for he pursued in his natural history studies the inductive or scientific method, which alone has given us substantial advances in knowledge. He acquired extensive and accurate knowledge concerning animals. His attainments would have been impossible in that day to one less remarkably endowed intellectually and without the unusual pecuniary and other aid extended by his friend and patron, Alexander the Great. With Aristotle zoology was first founded as a science; and his treatment of the subject shows an admirable balance and regard for essentials. He made many discoveries which have been confirmed only within the last century. Among other things, he understood correctly the general character of the formation of the individual as a progressive development from a simple germ to the complex adult. The word evolution is often extended to cover such development of the individual, in which case we speak of individual evolution in contrast with the evolution of the race or species. Aristotle, perceiving the character of the individual development as an evolution of this sort, extended the idea subsequently to the kinds of organisms and definitely conceived of the origin of the higher from suc-

cessively lower and lower forms, through the operation of a law, his so-called "perfecting principle."

Through the collapse of the ancient classic civilization and the crushing of Greek freedom of thought, the continuity of the kind of investigation and learning represented so brilliantly in Aristotle was completely broken. For nearly two thousand years no real successor to Aristotle appeared, the writings on natural history that have come down to us from these long centuries representing a surprisingly lower intellectual plane. Among the Romans, the poet Lucretius was much impressed with the evolution idea and in his "De Rerum Natura" represents the process as applying to all things, both living and inorganic. Lucretius, however, wrought wholly in speculation and fancy. The sort of thought that predominated in natural history at this time and during the centuries following is typified in the writings of Pliny the Elder, who lived during the first century A. D., and lost his life in the eruption that destroyed Pompeii. Long famed as the foremost naturalist of antiquity, we now know that Pliny added nothing to our knowledge; but that, as a shallow compiler, he wrought together the real and the mythical indiscriminately. His long influence was decidedly adverse rather than favorable to progress.

The world-renouncing spirit of the Christianity of the Middle Ages was not favorable to devotion to natural things; and, in fact, direct investigation of

nature was completely crushed. The writings of the time on natural history, like those of Pliny, which were their model, treated in all seriousness such mythical creatures as the phœnix and dragon along with the real, fact and fable being received without discrimination. Reverence for the scriptures, for the writings of the church fathers and for other early works was such that people came to think that all knowledge of worth was covered by them. The tendency was to settle all controversies through reference to these authorities; and, hence, the polemics of the time were essentially polemics on interpretation. The world passed thoroughly under the thraldom of book learning.

Speculation upon matters treated in scripture and the early church writers was rife. The greatest minds of these times dealt with the problems of the creation as presented in the two seemingly contradictory accounts recorded in Genesis and in fragmentary passages in Job and Proverbs. The question of the actual length of time occupied in the creation especially was made the subject of exposition and controversy for centuries; the question as to whether the material of which the earth and its inhabitants are composed preexisted or not was debated; and, among others, the question as to the method followed by God in the creation was similarly much considered. The dominant belief in this last matter, based upon certain conspicu-

ous passages in one of the scriptural accounts, was that the Creator molded directly with his hands all things living and dead. At all times, however, there was present and in some degree opposed to this the equally ancient idea of a creation in the beginning that was in large part potential. According to this, the impress of the Creator was given once for all and, under its power, the actual formation and unfolding of natural things was even yet continuing,—the creation occurring thus largely through the operation of secondary causes as an evolution process.

In the fourth century of our era, St. Basil, in the eastern church, declared that in the beginning, at the command of God, the waters were gifted with productive powers and that "from slime and muddy places frogs, flies and gnats came into beginning." Thus he held a belief in what we now term spontaneous generation. He asserted, further, that the same command which gave this generative power to the earth in the beginning should be effective until the end of the world. St. Gregory of Nyssa held practically the same views. In the western church, St. Augustine held still more free and positive opinions in this direction. Usually a rigid adherent to the letter of scripture, in the matter of the creation he freed himself from the general current of belief which interpreted the creation as one "like that by which a toy-maker brings into existence a box of playthings." In one of his writ-

ings we read: "To suppose that God formed man from the dust with bodily hands is very childish. God neither formed man with bodily hands nor did he breathe upon him with throat and lips." He advocates the growth doctrine and argues that, even though living things commonly arise naturally from various substances, God is still none the less their Creator, since the productiveness of such substances was necessarily involved in the potential form in the actual or primary creation. In the seventh century we find St. Isidore accepting the same thought.

This view of the creation continued to gather strength in the following centuries among churchmen and others. It came into favor with many because of a theological exigency. The number of animals known even at that time had become so large that, though grounds were found for doubling and trebling or enlarging in any conceivably possible degree the dimensions of the ark, it was seen to be impossible that the vessel should hold seven of each kind of living thing, as represented in one account, or even two of each kind, as stated in the other. Nor was it thought humanly possible that Adam could have given names to so many creatures. But the difficulty was removed at once by the view that only a limited number of forms were created in the beginning and that from these or directly from lifeless matter all the others had originated through the operation of a divinely imparted pro-

ductive power or through an evolution. In the twelfth century St. Lombard, in a widely influential theological treatise, accepts and elaborates this doctrine. He especially emphasizes the distinction between those organisms directly created in the beginning and those which were evolved in later time, between the primary and the secondary creation. St. Thomas Aquinas likewise accepts the doctrine, and urges particularly that all things were nevertheless brought into being through the word of God, either directly or virtually. "Nothing was made by God, after the six days of creation, actualaly new, but it was in a sense included in the work of the six days; * * * even new species have existed before in certain native properties." Some men believed, and supported the belief from scripture, that all the lower organisms originated through the operation of secondary causes and that man only was separately and directly created in the beginning. As this doctrine was extended further and further a reaction set in; and by some those who held or had held it were accused of heresy. In this reaction the Spanish theologian Suarez (1548-1617) was most prominent; and, following him, the special creation doctrine was long dominant.

It has been seen that from the earliest times down to that at which we have now arrived there was a belief in the generation of certain living things from lifeless substances, such as slime and decaying organic

matter; that is, a belief in what we now term spontaneous generation, or abiogenesis. With the reawakening of knowledge and inquiry at the close of the Middle Ages, there was a revival of the method of Aristotle in natural history. Men began to appeal directly to Nature through systematic observation and experiment, and tremendous strides forward quickly resulted. The basis for the belief in spontaneous generation in due course was questioned; and, finally, Redi, an Italian naturalist of the seventeenth century, as the result of experiment, was led emphatically to announce his famous aphorism, *"Omne vivum e vivo"* ("All life from life"), asserting that no living thing ever arose excepting from another living thing, a doctrine that has received stronger and stronger confirmation down to the present day.

When it thus appeared that no living thing arose from non-living matter, that spontaneous generation was a fiction, the thought was natural that the organisms of the secondary creation sprang exclusively from the more limited number formed in the primary creation. It became widely accepted among the learned during much of the eighteenth century that closely related species had descended in this way from a single ancestral form, that all the kinds of oaks had come from one kind of oak, and that all the cat-like creatures had descended from one form which alone roamed in Eden. Each group of closely related species

being termed a genus, we may say, then, that the view represented a single type of each genus as having been created originally and the various species actually existing under each genus today as having arisen from the original type through evolution. In the early part of the century Benoist de Maillet, in a theory of evolution which he at times forced to the absurd, clearly indicated a conception of the origin of all existing species from preceding and different forms.

However, in this same century, the eighteenth, "the immortal Swede," Linnæus, interposed weight of his great authority in the path of the growing belief in the evolution of species. As a young man he had shared in the then generally accepted belief in the common descent of all species of the same generic group. Linnæus in later years developed a system for accurately designating species, the so-called binominal nomenclature, which is still in use and for which its author is chiefly famous. From all parts of the civilized world students came to him, and to these he taught the system. The result was a tremendous impulse for searching out, describing and naming by the new nomenclature animals and plants from all countries of the globe. Species took on a dignity and importance they had never had before; and Linnæus soon began to teach that species had not evolved but that they were fixed and immutable entities created in the beginning with all their essential characteristics and that, accord-

ingly, there were in the world today just as many species,—no more and no less,—as had been originally created. His methods and teachings were spread by his students over the civilized world and became generally accepted by the clergy and the other educated classes. Thus came into being the doctrine of the special creation of species in its rigid form as it has existed in modern times.

While the influence of Linnæus and his students widely checked the current of belief in evolution, it did not completely stop it. Working during the same century was the French naturalist Buffon, a man of remarkable intellectual powers and brilliancy. He advocated the evolution doctrine and worked out clear and original ideas concerning it. However, he was early made to feel the opposition of the Linnæan school. Through the theological faculty of the University of Paris he was finally forced to recant; and thus the development with him of a system of evolutionary thought that would likely have had powerful influence was effectively arrested. But others took up the thought and carried it forward; it would not down apparently. Goethe in Germany (1790) was an ardent and brilliant advocate of the doctrine. In England, Erasmus Darwin (1794), grandfather of Charles Darwin, presented a form of it; and various others dealt with it from one viewpoint or another. Of considerable importance was the work of Treviranus in France

who, in 1802, set forth a fully elaborated theory of evolution, including definite views as to the factors concerned in the process. In this theory all higher organisms were regarded as having arisen from forms more simple. Each form was supposed to be receptive to external conditions in such a way as through them to become gradually more and more complex in structure. Each form was supposed, that is, to have been simple in the beginning but through successive modifications produced by the action of environmental forces to have progressed to its present condition. No form was believed to have become extinct in any other sense.

The French naturalist Lamarck (1744-1829) is justly regarded as the founder of the complete modern doctrine of evolution or descent, although, naturally, very much that he taught in connection with it is now demonstrably false. In a treatise entitled *The Philosophy of Zoology,* published in 1809, he presented his theory fully. He believed that in the beginning the organisms of lowest structure arose through spontaneous generation; and that from these first organisms were developed, through gradual changes extending over a vast period of time, all existing species of animals and plants. The many species were supposed to form one continuous chain leading from lowest to highest. Man represented the top of the series and was supposed thus to have been derived from the

ancestry from which other animals had developed as lower "links." As to the factors of the evolution, Lamarck did not believe with Treviranus that external influences directly had much effect, but attributed changes mainly to the effects of use and disuse, which effects he believed to be inherited. Changes in environment, he contended, were influential only in so far as these changes affected the activities of the organisms. The eyes of animals living in caves and other dark places had degenerated because not used; and the necks of giraffes were long because of the continual stretching to which the necks of the ancestors had been subjected in their efforts to reach the leaves of trees for food. Lamarck's work produced considerable stir in France at the time of its publication; but its influence was not extensive. In more recent times Lamarck has had a school of followers, the so-called Neo-Lamarckians, who agree with him in believing that the effects of use and disuse in the life of the individual can be transmitted by heredity to the offspring and that the Lamarckian factor is hence a real one in evolution.

A new element now began to enter as a more and more powerful factor into discussions as to the origin and history of living things upon the earth. Fossils had long been known but had not been given profitable consideration. By some they had been put aside as beyond the field of scientific research; others

thought of them as remains of animals and plants stranded at the time of the Flood; not a few had accepted the view that they were due to the influence of the stars upon the earth or to the effect of a creative or fertilizing breath which when falling upon suitable materials brought living things into existence but when acting on ordinary inorganic materials produced merely fossil forms; some asserted that they represented rough models of animals which had been rejected by the Creator; while finally there were still others who devoutly maintained that these same fossils were placed by the Creator to bring to naught the efforts of proud man. Georges Cuvier (1769-1832), the foremost naturalist of his time and one of the greatest in all history, first proved beyond any manner of doubt that fossils were the remains of animals that had actually lived in the past and established Paleontology as a science. This proof of the former existence of great numbers of animals distinct from those now living was, of course, a death blow to the Linnæan dogma that as many species now exist as had ever been created. Cuvier, in explanation of the occurrence of great numbers of fossil remains in deposits or strata of different geological ages, advanced what is known as the Cataclysm Theory. Denying any actual continuity between the different strata or the fossil forms which they contained, he asserted that there had been a number of successive creations. The earth having been

fully inhabited was at the end of each period subjected to a great cataclysm of some kind or another which completely destroyed all forms of life and changed the face of nature generally. By another creation the earth then became filled with living forms of a different order which, in due turn and course of events, were themselves swept out of existence. Each period was characterized by its own peculiar types of plants and animals which were more and more different from existing forms the older the period.

In 1830 a heated controversy arose in France between the advocates of the doctrine of descent and those who, under leadership of Cuvier, adhered to the idea of a number of special creations, this controversy culminating in a famous debate before the Academy of Paris between Cuvier and Geoffroy St. Hilaire. St. Hilaire had begun to develop a theory of evolution as early as 1795. In the thesis which he attempted to maintain in the debate was the fallacious conception that all animals, if arranged according to their relationship, would constitute a single series, leading directly from the lowest at one end to the highest at the other. It was rather easy for Cuvier with his remarkable knowledge of comparative anatomy to expose clearly the fallacy of this notion. He contended that animals formed a number of co-ordinate groups in each of which a certain type of structure dominated,—his so-called Type Theory—which we now know also

contained considerable error. Cuvier's triumph was so complete that the question of descent of organisms practically disappeared from France for a long time. The triumph was due, firstly, to the false idea of the linear arrangement of organisms presented in the theories of Lamarck and St. Hilaire; and, secondly, to the large proportion of speculation to fact in them. Thus, for a time, the Linnæan doctrine of the creation of all species separately, in the amended form, was entrenched more strongly than ever.

Crushed in France, the evolution movement now passed chiefly into the British Islands where the work in Paleontology and Geology especially had an important bearing. The foremost geologist of the day was Sir Charles Lyell (1797-1875), a man of deeply religious character and a devout Christian. In his earlier writings he had opposed strongly the theory of Lamarck and had adhered to the Cuverian notion of successive creations. In 1832, however, in his epoch making treatise "The Principles of Geology," Lyell gave up completely the idea of discontinuity in the geological record and set aside once for all the cataclysm theory. He showed clearly that in order to understand the structure of the earth it was wholly unnecessary to assume catastrophic changes—but that this structure must be interpreted as the result of a growth or gradual development in which the factors of change were the same as those still operating. The past history of

the earth can only be understood when interpreted in the light of present processes.

Robert Chambers published in 1844 an attractive and widely read little volume under the title "Vestiges of Creation," in which he presented the hypothesis that all animals from the simplest and first formed up to the highest had resulted from the operation of two impulses given in the beginning once for all by the Creator. One of these was a force tending to drive animals upward to higher and higher organization and estate, the other a force tending to modify the direct effect of the former by altering the organisms in accordance with differences in environment. Although the spirit of the book was thoroughly devout, it met with a storm of protest and adverse criticism from the clergy. So few were the elements of fact in the work, so purely speculative was it, that it had little effect beyond calling forth in some minds for the first time the thought that such a process might be entirely possible.

By the middle of the century an unprecedented activity along lines of research in natural science had resulted in the accumulation of a great mass of facts bearing upon the creation question and demanding an explanation simple, uniform and comprehensible. The science of Paleontology had made great advance, and our knowledge of the succession of organisms in time upon the earth had greatly increased; embryologists,

led by the illustrious Von Baer, had reached deep generalizations upon the processes concerned in the genesis of the individual from the egg; explorations in the different countries of the earth had brought out peculiarities in the geographical distribution of living things; while the knowledge of the nature and degree of structural relationship between animals had been greatly extended through advances in comparative anatomy.

Herbert Spencer published in 1852 an essay in which he argued for the doctrine of descent as against that of special creation. Considering the results from the diverse fields of investigation mentioned, he contended that they were clearly explicable and mutally consistent in the light of the doctrine of the common descent or genetic relationship of all organisms; but that they were inexplicable and meaningless upon any other hypothesis that had been suggested. He argued that the interpretation of phenomena as resulting from a growth process, from an evolution, had been independently made in various fields of enquiry. Astronomers had so explained the origin of the solar system out of diffused matter; geologists had, without consideration of the work of astronomers, arrived at the conclusion that the structure of the earth was the result of a gradual development; historians had shown that social institutions were not made, but grew; and philologists had demonstrated the origin of languages

through gradual evolution and divergence. "If then," he wrote, "the recognition of Evolution as the law of many diverse orders of phenomena has been spreading; may we not say that there thence arises the probability that evolution will presently be recognized as the law of the phenomena we are considering? * * * The discovery that evolution has gone on or is going on in so many departments of Nature, becomes a reason for thinking that there is no department of Nature in which it does not go on." Spencer's essay seems to have won but few to the theory he advocated, notwithstanding he believed the evidence presented had given to it a warrant "much higher than that of very many beliefs that are regarded as established."

On July 1, 1858, two papers were presented jointly before the Linnæan Society of London which mark the culmination of the movement toward evolution. One of these was a memoir by Alfred Russell Wallace who, as one of the fruits of many years' study in the forests of Brazil and the Malay Archipelago, had formed a definite hypothesis to explain evolution in living things. The other paper was by Charles Darwin who had independently arrived at precisely the same hypothesis and had been testing and developing it quietly for twenty years, in all that time informing no one of it excepting his friends Hooker, the botanist, and Lyell, the geologist,

to whom he had imparted it under bond of secrecy. This hypothesis thus independently arrived at by Wallace and Darwin is the well-known theory of Natural Selection or of Survival of the Fittest, as afterward termed by Spencer. During the next year, 1859, Darwin published his treatise, *The Origin of Species by Means of Natural Selection,* in which he presented a full outline of his theory together with a great mass of thoroughly digested facts drawn from every field of natural science in support of it and the general doctrine of evolution. These facts "were presented with such minute research, wide observation, patient collation, transparent honesty, and judicial fairness that they at once commanded the world's attention."

The theory of Natural Selection, or rather the general idea of it, was not first conceived and stated by Wallace or Darwin, although not only this but also that of descent in general have been widely attributed, outside of scientific circles, to the latter. Even among the Greeks, the theory of Natural Selection had been anticipated in a crude and purely philosophical form. Darwin owed the idea in his own mind, he tells us, to a work by Malthus, *Principles of Population,* first published in 1798. In 1813 Dr. Wells developed a theory of Natural Selection to account for the formation of varieties in the human race. And, again, Patrick Matthews, in 1831, gave a statement of the same principle. Darwin is justly accredited with the theory of Natural

Selection however, because he was the first to present it in scientific form and to show a degree of plausibility for it in fact and experiment. Hence, Darwinism is uniformly used today among naturalists as the equivalent of Natural Selection. Popularly the whole theory of descent is attributed to Darwin because he was the first man to compel the attention of the world widely to it; but it is erroneous to use Darwinism under this mistaken notion as a synonym of the general doctrine.

The first element entering into the theory of Natural Selection is what Darwin terms the Struggle for Existence. Animals and plants tend to increase in geometrical ratio; but, as a matter of fact, the number of individuals of different species remain on the average unaltered from year to year. Most of the offspring produced in a state of nature do not live to leave descendents, being killed off through the forces of the inorganic environment, by living enemies, in unsuccessful competition with their fellows for food, through diseases, or otherwise. Without these checks, as a little figuring will show, the slowest breeding animal or plant would quickly overrun the whole face of the earth. The second element in the theory is Variation. Of the descendents of given parents no two are precisely alike, either in structure or in physiological capacity. They have their more or less pronounced individual differences. The third element in the theory, finally, is Natural Selection proper. This simply means

that those individuals which vary in a way best to undergo the struggle for existence in the environment in which they have the opportunity of living will survive as against those less favorably endowed. Only part of the young born can possibly reach maturity, and this part, naturally will be composed of the strongest or otherwise fittest. Those escaping or overcoming the adverse elements of the environment, those successful in the struggle for existence, will alone leave offspring; and this offspring will inherit in some degree the variations which gave the parents the advantage. By a repetition of this weeding out, and the accumulation of variations in the favorable directions, it is represented that in time changes of any degree whatsoever have been brought about and that the many different forms of organisms have been developed and fitted, or adapted more or less remarkably, to their different environments.

Upon the publication of *The Origin of Species* a few biologists placed themselves at once on the side of Darwin and Wallace; others, more numerous, acceded to the main doctrine of descent but hesitated as to the efficacy of Natural Selection as an explanation; while others took up a position wholly in opposition. A sharp but rather short scientific battle ensued, at the conclusion of which a large majority of the more eminent naturalists had arrayed themselves in favor of the general doctrine of descent, though many of these were

not convinced that Natural Selection was a sufficient explanation of the process. The last great naturalist to hold out against the evolution of species was Louis Agassiz, a Swiss by birth and an American by adoption. Agassiz had received his theory concerning past life on the earth from Cuvier and had elaborated it in his own mind in accordance with new facts as these had from time to time been brought forth. To this theory he was true until his death, the last representative of the Cuverian school. All Agassiz's efforts to check the evolution theory served rather to advance it; and the chief results of his own brilliant researches are today construed in favor of it. Of the great naturalists who obtained their training under Agassiz and received the inspiration and direction of their life work from him, not one has followed in his footsteps as to evolution. All have worked in the cause of the theory he combated. Opposition on the part of the abler theologians soon ceased; for they came to recognize that their position as rational theists was strengthened rather than weakened by the conception.

Today, fifty years after the publication of the *Origin of Species,* the general doctrine of evolution or descent is regarded as an established law in biology. The position of the doctrine in the scientific world may be judged from the following statement made by President David Starr Jordan: "All contrary hypotheses have long since ceased to work. The theory of

evolution as the method of creation of species is as well attested as the theory of gravitation. All biological investigation must assume it; without it such investigations are impossible. * * No naturalist whose studies give him the right to an opinion on the origin of species now holds the old notion of separate creation for each species and its organs. No one could hold it and look an animal in the face." Similarly Prof. S. H. Gage has written: "To turn the zoologist back to the old notions of special and independent creation for each species or group of animals, would be like leaving the astronomer only the sun-god and the angels to direct the planetary movements." And Prof. Vernon L. Kellogg in a recent work says: "Organic evolution, that is, the descent of species, is looked upon by biologists as being as proved a part of their science as gravitation is in the science of physics or chemical affinity in that of chemistry."

Since Darwin's day extensive researches and investigations and many ingenious speculations have been directed in an effort to ascertain definitely the factors controlling evolution, and, as a result, various pertinent theories and hypotheses, which we cannot here consider, have been advanced. Natural Selection from the very first has been far from generally accepted as the sufficient explanation of evolution. Its rival hypotheses merit still less the verdict of "sufficient" or "proved." But while biologists are divided into

various "schools" over the question of controlling and activating factors, these schools are one in assuming as a demonstrated fact or law the creation of species through evolution.

THE NATURE OF EVOLUTION---WHAT IT IS AND WHAT IT IS NOT.

In its most general sense., i. e., as the law of continuity, it [evolution] is a necessary condition of rational thought. In this sense it is naught else than the universal law of necessary causation applied to forms instead of phenomena. It is not only as certain as—it is far more certain than—the law of gravitation, for it is not a contingent, but a necessary truth like the axioms of geometry. It is only necessary to conceive it clearly to accept it unhesitatingly.—LeConte.

The evolution idea was grasped, as has been seen, by certain master minds back through the ages, though for long only as a philosophical conception. Beginning its actual conquest of the general intellectual field only in the past century, it rapidly forced acceptance until today it is undoubtedly the dominating influence in the world's thought. There is no portion of the field of systematized knowledge that has not been transformed and vivified through its influence. It is now regarded by many as perhaps the grandest conception attained through the scientific method. With its establishment was also completed that of the reign

of universal and persistent law, the foundation stone of all modern science. Yet, although evolution is a word in very general use, there is great vagueness in the minds of most people as to what it really is and as to the basis upon which it rests in the scientific world. It is the purpose in the present chapter to discuss in an elementary way the content of the theory and to point out some of the commoner misapprehensions of it.

The Greek philosopher Heraclitus (Ephesus, 536-470 B. C.), in his efforts to understand existence, was deeply impressed with the universality of change, so much so that to him never-ceasing alteration, continuous movement, became the basic process, "the Lord of the Universe." He said, "You cannot step twice into the same rivers, for fresh waters are ever flowing in upon you," and the life of man, he said, "is kindled and put out like a light in the night time." A flame seemed to him, indeed, to typify the universe; for while presenting an appearance of permanence it was forever shifting and forever passing away into gases above while fed from fresh material at its base. Everything, he taught, is in a state of change, of becoming, of continual flux. Nothing exists which, in his way of looking, is not becoming different, becoming something else; and nothing has existence excepting in relation to this process.

Heraclitus in this, partially perceived a great truth,

of which the evidences increase the more in number and weight the more we contemplate nature and life. For natural knowledge shows us with ever-increasing emphasis that nothing in the material universe exists which is not gradually changing into something different; that perhaps the most obvious feature of the universe or cosmos, indeed, appears as this impermanence of any particular state. Rest cloaks unperceived activity; and "seeming peace is silent and strenuous battle." The very world into which we are born becomes different while we are still in it. Things which seem permanent appear so only because of the slowness of change, of the slightness of the increment, —or of the brevity of the period of observation. Moving objects seen by a flash of lightning at night seem stationary. Geology has taught us impressively how vast may be the results aggregating through the long-continued action of slight agencies. Thus the state of the universe at any given time appears as but a phase of incessant change.

In the midst of all this change and transformation, however, we always find order. Events do not happen in haphazard or chance ways; phenomena succeed one another in a regular and unvarying sequence. For the appearance of any given phenomena there always is found to be some essential precedent condition. In ordinary language we express this fact by saying that every effect has a

"cause;" that the same cause always precedes the same effect. The incessant changes occurring in the universe and all its parts thus appear as the incidental expression of a fixed order in which every stage is the effect of definite causes, each one of which always acts in its own unvarying way, producing its own particular effect and no other. The world of today is a development from, a result or consequence of, that of yesterday; just as the world of tomorrow will grow out of and be determined by that of today. The statement of this general principle of the orderly development of nature, step by step, is what is meant by evolution. It is a name for the law of change in the universe—for the cosmic process. The universe has been compared to a scroll partly unrolled. The unrolled part is taken to represent the history of the universe to the present time; the rolled part its future, determined probably, but not yet realized. Hence, evolution has been aptly spoken of as the "unrolling of the universe." It should be properly emphasized, however, that evolution is in no sense an explanation of this cosmic process; it is merely a statement and partial description of it and its results.

What is stated as true of the universe as a whole is held to be true of its parts, the belief being that "not merely the world of plants, but that of animals; not merely living things, but the whole fabric of the earth; not merely our planet, but the whole solar system; not

merely our star and its satellites, but the millions of similar bodies which bear witness to the order of boundless space, and has endured through boundless time, are all working out their predestined courses of evolution" (Huxley). And "in the transformed attitude of the intellectual world today, the mooted question of the hour—the evolution of the atom—finds a fair field, wherein evidence needs but to accredit itself duly to have its place and weight duly accorded it. If the atom shall show an authenticated pedigree it will easily take its place in the procession of the derived, with the plant, the animal, the earth, and the stars" (T. C. Chamberlin). Thus workers in very diverse fields have perceived that, to understand the things with which they deal, it is necessary not only to know them as they are at present but to know the entire succession of the phases of which they are the outgrowth; and, acting in the light of this perception, they have transformed what were formerly merely a chaos of disconnected and superficial observations into orderly records of the unfolding drama of the Cosmos, each of which records in appearance shows a progressive development out of a condition of relative uniformity to conditions of greater and greater complexity, but with here and there an occasional line of regression.

While evolution is thus a universal or cosmic process, the word as most generally employed applies

particularly to the development of existing living organisms out of those of the past. That is, in biology, the word is applied to the theory according to which all kinds of living organisms have descended from one or but few original types, with modification and ever repeated divergence along distinct lines. All existing species are regarded as resulting from modifications in the descendants of pre-existing species, as these pre-existing species were modifications of their immediate predecessors and so on back to a common stock of primitive character. This doctrine was formerly more commonly known under the name of the transmutation theory; and today it is also sometimes indicated as the theory of derivation or descent. Because accurate knowledge concerning living things in general or of the established laws and principles of biology are but little diffused generally, most people do not form readily a complete conception of this theory and the basis upon which it rests. For this reason it will be advantageous to review some results in a quite distinct science, where the significance of known facts should be more readily perceived, in order to make clear the meaning of analogous facts in the biological field.

Like botany and zoology, the science of language is one in which classification plays an important part and in which the method is chiefly that of comparison. Philology as a science has been carried to a high degree of perfection, particularly in the field of the Euro-

pean languages, in which the methods have become remarkably accurate and almost unerring in their results. For illustrative purposes we shall consider some facts in the developmbent of these languages which are matters of history or of clear induction, scarcely admitting of doubt, and hence universally accepted. But first something as to the processes of change of language in general may profitably be discussed.

Every language is in a condition of continuous growth and alteration. It matters not what language you may select, if there exists any record of the tongue as it was spoken at some time at all distant in the past, you will readily see that the language is different, and different in most cases in proportion to the length of time intervening between the date of the record and the time of observation of the living tongue. The English of only a century ago was considerably different from that of today, there being much in it at present which would be understood only with difficulty by one who had acquired the tongue as it was spoken at the earlier period. "If we were to hear Shakespeare read aloud a scene from one of his own works, it would be in no small part unintelligible (by reason especially of the great difference between his pronunciation and ours); Chaucer's English (500 years ago) we master by dint of good solid application, and with considerable help from a glossary; and King Alfred's English (1,000 years ago), which we call Anglo-Saxon,

is not easier to us than German." It is so with the modern German as compared with the forms of the ancestral speech recorded during earlier centuries; it is so with the Greek, the Latin, the Sanscrit, and the Persian.

Change in language may manifest itself, in the first place, in alterations of materials still retained in the language; either as a change in the uttered form of words or as a change in content or significance; or the alteration may be in both respects simultaneously. A word may change in form, in function, or in both. Thus the Greek word *episcopus* is primarily a compound meaning an "over-seer." When Christianity spread to such an extent that it became necessary to place some one over the congregations in different places, the word *episcopus* was selected to designate the person appointed to the office. The word was thus carried to every country into which Christianity spread; and today its representatives have become restricted to its altered ecclesiastical significance. Furthermore, it has undergone varied modifications in form in different languages. In English it is now *bisho*p, in German *bischof,* in Spanish *obispo,* in Portuguese *bispo,* and in Danish merely the one-syllabled *bisp.* In French it has become so altered that not a single original syllable is preserved—*evcque.* As a further illustration of marked change from the original meaning, we may take our word *bank.* Originally this word English

meant merely a bench, as the corresponding form still does in German and other related tongues, and was applied to the bench of the money-changer in the market place. In case the money changer failed, his *bank* was broken and he was driven from the market place—hence word *bankrupt,* who today has far different things to face than having his bench broken. In using the word *influence* we no longer think of a special control supposed in the days of astrological belief to be exercised by the heavenly bodies, to which usage the word was at one time confined; when we speak of a *lunatic,* we do not now think of one who was born under the evil influence of Luna, the moon; a *volume* to us is not a parchment rolled up when not in use; nor is *paper* tissue from the papyrus plant. Sometimes a single original word gradually takes on different forms or pronunciations in accord with two or more meanings attached to it; such are *con'duct* and *conduct'; also* and *as; through* and *thorough; one, an* and *a; gentle,* and *gentile.*

In the second place, change in language may occur through the complete or partial disappearance of words or expressions once in common use. Whole words may disappear or grammatical forms may do so. Among different peoples conceptions represented by certain words have from time to time disappeared, and with their going out the corresponding words likewise have become extinct; words may be crowded completely out

by the incoming of other words meaning the same thing and for some reason winning a preference among the people; or words and phrases may simply go out of style and be dropped for no other apparent reason than mere caprice. In any tongue we may choose we shall find a considerable amount of material showing this process of disappearance in all stages, from words or expressions that are merely unusual, through those that are rare excepting in a particular style, to those that have become to most wholly unintelligible and those quite out of use and known only through records of an earlier day. There was a time when in the language of our ancestors the names of the gods Thor, Woden, and Freya were as commonly in use as are Christ and Moses with us; but, with the going out of the belief in these, the words also dropped away and in our present language are preserved to us only in a concealed form in the names of the days of the week—Thursday, Wednesday and Friday. The old Anglo-Saxon words *reste-daeg* (rest-day) and *leorning-cnihtas* (learning-knights) have been replaced by the Hebrew *sabbath* and the Romanic *disciple* respectively. We one time had in English a word *weorthan*, which meant *to become* and corresponded precisely to the German auxiliary *werden;* this died out completely without leaving us any substitute. The common Latin word for horse was *equus;* but in all the descendants of the Latin the word has become replaced by some mod-

ification of *caballus,* which in the Latin itself was only vulgarly used about as we now employ "plug" or "nag."

Finally, change may occur in a language by way of addition of entirely new words or phrases to meet the demands for expression of new ideas or conceptions and relationships among the people; or words already in use may have new meanings attached to them. In this way our language has at one time or another taken up many foreign words either with their original meanings preserved or with a desired meaning attached to them; such are *banana* and *tabu* from the Polynesian; *seraph* and *jubilee* from the Hebrew; *algebra* and *cipher* from the Arabic; *chess* and *shawl* from the Persian; *calico* and *punch* from the Hindu; *tea* from the Chinese; *canoe, potato* and *caucus* from the Indian; *mesa* and *canyon* from the Spanish, and so on; while from the Greek we have formed outright a long list of new words, such as *telephone, phonograph* and *microscope.* On the other hand, many new words are formed through the compounding of those already in use in the language and this is doubtless the most important method of all primarily; thus were formed *buttercup, butterfly, headland, steamboat, railway* and a host of others. The *ly* which we add to adjectives to form adverbs, is the representative of an old case form of *lic (lice),* corresponding precisely to our *like,* which was formerly added to adjectives just as today

we add it in such compounded forms as *God-like,* which we, likewise have in the form *Godly;* similarly *lovely, truly* and similar words, are modifications of the compounds *love-like, true-like,* etc. Such compounding, in fact, with subsequent alterations such as this, was at the basis of the most important growth-process concerned in the formation of European languages.

All such differences or changes as we have mentioned and through which a tongue in time becomes totally altered, begin in individual peculiarities of expression which, perchance, are generation after generation taken up by a larger and larger circle of people and become generally accepted in a particular locality or finally in the country at large. If a community is isolated, the peculiarities arising in it are confined to itself, and thus, in time, a well marked dialect results. The greater the isolation and the more different the external circumstances or environment, the more rapid will be the dialectic growth. Divergences between dialects are at first rather slow; but once started, the separation becomes more and more rapid. Every language under the sun shows this tendency toward dialectic growth, even in countries where the existence of a written literature works strongly against it. In France there have grown up fourteen or more well marked dialects; in Norway nearly every valley has its own type of Norse; and in Greece scholars enumerate nearly

seventy; while in languages that have not been under the conserving influence of a classical literature, such as the Frisian, these linguistic variations in all stages of development are still more abundant.

Following the conquering Roman arms, the Latin language spread over much of southern Europe. Among the alien or hybrid races of this territory variation and divergence were soon manifest; and, growing out of minor dialects which differed at first but little, Spanish, French, Portuguese and other of the so-called Romanic tongues, with the progress of centuries, became thoroughly established, considerable literature existing in the more important ones from the twelfth century, or, in some, considerably earlier, forwards, through which the later steps of growth may be followed with especial thoroughness. The literary dialect of Latin continued in use only among the learned, and gradually ceased as a spoken tongue altogether. Latin in all its dialects and modifications and all the languages of later times thus genetically related to it, constitute the so-called Italic class of languages.

Evidently the dialects and languages of this class present very different degrees of relationship to each other. Figuratively, we may say that the living languages of the class as existing in their dialects are comparable to clusters of the ultimate twigs of a tree, each cluster of twigs growing out from the same branch representing a single language, such as French

or Spanish. The branches bearing the ultimate twigs, in turn, would extend out from a common limb, the Latin. This larger limb is dead as are also the branches going out from it, the only living portions being the smallest twigs or only the apical, growing tips of these,—as we must consider them to die out at the base as they are extended terminally. Extinct tongues or dialects constitute either portions of the dead branches or limb or else offshoots from them which died out completely in the past.

In addition to the Italic there are represented in Europe other classes of languages co-ordinate with it. In each of these classes the existing languages are clearly descended from a common original stock out of which they grew with divergence and redivergence such as described for the Italic above—though we have not in all actual records of the earlier steps. That is, existing dialects are traceable back from the present forms along converging lines to a common form or branch, which being similarly followed inductively still further back, is seen to converge with others of the same rank into a common stock comparable to that represented by the Latin in its class. Such a class is the Teutonic in which there are three main branches, namely, (a) the High-German, represented today by the main dialects of Germany, (b) the Low-German, represented by the dialects of English, Dutch, Frisian and those of North Germany and (c) Scandinavian, the living representa-

tives of which are the dialects spoken in Denmark, Sweden, Norway and Iceland. Another important class is the Celtic, of which there are also three branches, (a) one including Welsh, Armorican (Brittany), and Cornish (now extinct), (b) a second including Irish, Manx and Scotch Gælic, and (c) the third the extinct dialects of old Gaul. The other classes of European langauges are the large Letto-Slavic, which includes the languages and dialects of Russia, Bulgaria, Poland, Lituania, etc.; the Hellenic or Greek; and the Illyric. In each of these classes the truth of the following statement, made many years ago by the philologist Grimm, appears evident: *"Dialects develop themselves progressively, and the more we look back in the history of language the smaller is their number and the less definite their features. All multiplicity arises from an original unity."*

We have seen previously that every language is continually changing, and that when we are able to trace it back in time by means of records that have been preserved from the earlier periods it is found to differ mainly in proportion to the time that has elapsed; and also that, when a portion of a people becomes in any considerable degree isolated, dialectic differences inevitably begin to appear. Diverging from the original language slowly at first, the angle of separation becomes ever more and more wide. The two dialects do not change in the same way. Words and phrases alter

in form and meaning in one that may retain nearly the original form and meaning in the other and vice versa; words at first common to the two may become obsolete or wholly extinct in one and not in the other; while new material in the way of borrowed words, compounds of the old, and new grammatical devices are inevitably different in the two. Evidently, then, the more recently the separation took place, and consequently the fewer the generations through which the language has been transmitted, by tradition or social heredity, the more complete must be the correspondence between the two in content and construction. We must accept as established beyond doubt, moreover, that any such "*correspondence in the material of different languages, if existing in measure and kind beyond what can be accounted for as the result of accident or borrowing, is explainable only as due to the separate tradition of an originally common tongue, a tradition which preserved a part of the original uses, while it modified or discarded other parts, or introduced what was new, to such an extent as to obscure, and perhaps even to hide, the evidences of former connection*" (Whitney). It likewise follows clearly that the *proportion of materials and special devices corresponding in any two languages is a direct indication of the degree of real relationship between the two and of the comparative period of time*

elapsed since their initial divergence from a common stock.

By the method of comparison pursued according to thoroughly established canons, it was long ago shown that Latin and Greek are closely related and that they must have arisen by slow dialectic variation from the same tongue after the two peoples subsequently known as speaking these languages had separated from one original band or tribe. The original tongue has with much certainty been reproduced in its more essential features of word and grammatical materials. In the same way all the languages of the other classes previously mentioned as existing in Europe are regarded as demonstrably descended from the same ancestral language as the one from which the Helleno-Italic branch is an off-shoot, in the same sense in which the Romanic languages previously discussed are the more recent descendants of the vulgar Latin of the Western Roman Empire. Now in India and some adjacent parts there are two classes of languages—the Indic or Sanscritic and the Iranic—evidently more closely related to each other than to any other classes of languages and yet no less clearly coming before their own divergence from the same stock as the European classes. Hence, the languages of India and Europe are grouped together by all philologists in one great family, which is commonly designated as the Indo-European or as the Aryan family. Every qualified investigator who has

given his energies to the study of this family has inevitably reached the conclusion that there was a time when the ancestors of all the various peoples to whom the languages considered above primarily belong, lived together in one clan and spoke a common tongue, which could not have been yet Sanscrit or Greek or German, but which must have contained the dialectic germs of all. By the spreading and emigrations of bands from this limited clan, the family reached its present wide distribution over India and Europe.

The language spoken by the Aryan clan before its breaking up into sub-tribes has been reconstructed in its main features. We may now briefly explain what, according to the most widely received view, must have been some of its salient characteristics and the principles according to which the languages of later times have been built up out of it. In reconstructing any extinct language, in line with the presentation made above, we must first thoroughly ascertain the processes by which languages change at present or have changed within historical times. Having grasped these processes we proceed backward by strict anological reasoning, assuming like results to proceed from similar causes, and never assuming other causes so long as this process gives legitimate results. Now by pursuing this method in any one of the classes of Indo-European languages we shall clearly see that the most important element in the progressive changes in the language

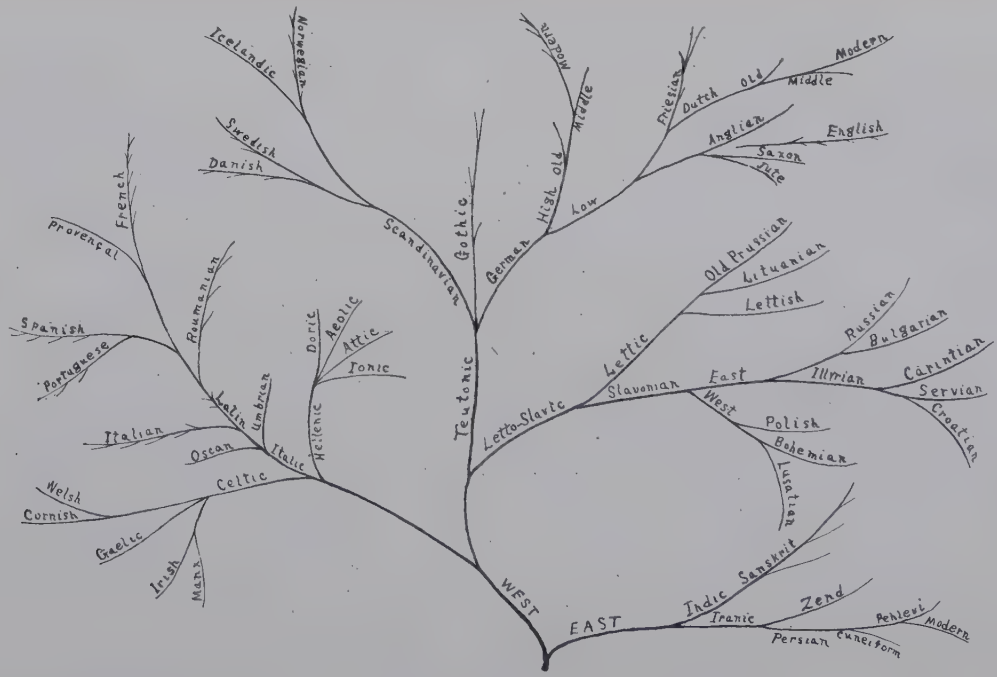


Fig. 1. Diagram designed to show the approximate relationship and lines of descent of the principal languages of the Indo-European family. Note the repeated branching and divergence characteristic of the evolutionary process.

has been the simple principle of addition of words or element together in the precisely the same way as our ancestors compounded *like* with adjectives to express the adverbial idea. Taking the word *did,* by tracing it back we find that it itself most likely is the equivalent of a compound of the verb *do* with itself, *do-do* (*dyde*), this doubling of the simple verbal stem having been the method of formation of the past tense primitively (as may be seen in Sanscrit, etc.). As an example from the Romanic class, let us enquire whether the past (imperfect) forms of the verb *to love,* for example, may be similarly shown to have been compounds in which the added portion had at one time an independent existence and meaning. In Spanish the imperfect is *amaba* and in Italian *amava,* I loved or I was loving. Evidently the terminations *ba* and *va* added to the present to form the past are different modifications of the termination *bam* in the Latin. But neither in Italian, Spanish, or Latin has this ending any separate existence or meaning. By going further back, by the comparative method, however, we find that this ending *bam* has a separate existence as a verb meaning to be (*beom* in Anglo-Saxon, *bhavami* in Sanscrit, etc.). As a final example may be mentioned the third person singular in the present tense of the verb *to be* as represented in the different Aryan languages (English *is,* German *ist,* Latin *est,* etc.) In each case the form is regarded quite generally as going back to the

compound *as-ta,* in which *as* is the root indicating being and *ta* is a demonstrative meaning that or it.

When in this way we are able to follow out the history of inflected words, of whatever order, stripping off each subordinate particle as soon as it is seen to have an independent existence, we have left frequently words merely of but one syllable, of which the great majority are of very general verbal character, but equally usable as other parts of speech are with us at present, and the other smaller class of the demonstrative class like *ta,* above mentioned. Thus are we led to the conclusion that the historical beginnings of the formation of Aryan languages lay in a body of simple, chiefly uninflected, words. Since we have seen that certainly most formative elements in these languages have been derived by compounding or accretion "then only that can have been original which is left when these have been stripped off to the very last one; and what is left is the root; and it is, in our family of languages, a monosyllable," i. e., the root and word were often the same in form.

This period must necessarily have been antecedent, then, to the development of most means of grammatical distinctions. There could have been few inflections, there could have been in strictness no parts of speech. The simple one-syllabled words "indicated each some conception in entire indefiniteness as concerns its relations, neither viewed as the concrete name of an object,

nor as attribute only, nor as predicate; but as equally ready to turn to the purposes of any of the three." From a body of such simple words, or partly such, which seemed to number not more than 800 or 900, the simple process of accretion or compounding is alone practically sufficient to account for the whole diverse and often highly complicated grammatical structure of the Indo-European languages. The principle underlying this compounding is clearly the effort at economy, which, continuing in force, after leading to the formation of compound words and aggregated, phrazes, brings on their subsequent decay or wearying down into the shortest or most easily manageable and agreeable form compatible with their acquired function, as has previously been illustrated. Of course, there are in European languages inflections which cannot be traced back historically to separately significant words; but they may likewise be accounted for upon the assumption that their derivation was like that of those which may so be traced back inductively. The importance of compounding generally in the formation of new elements will be impressed upon any one who will examine a few pages of a good dictionary. Differences of opinion on details of the process do not in any way alter the general agreement as to the common origin of the Indo-European tongues.

To illustrate the plasticity of these simple original Aryan words and roots, and how extensive and varied

may be the family of words in time growing out of a single one through simple processes a single example, given according to findings of Max Muller, will suffice. The root *mar,* meaning primarily to grind down, also under certain definite conditions assumed the form *mat* (l and r being equivalent), *mri* (Sanscrit), *mra* and *mla,* while the two latter forms in Greek assumed the forms m*bro* and *mblo* and sometimes, through the dropping of the initial m, *bro* and *blo.* From the primary meaning of *mar* it is easy to see how the word for mill in the languages of all the European classes came from this root. (Eng. *mill,* Old German, *muli,* Latin, *mola,* Greek, *myle,* Irish *meile,* etc.); hence also the words for *millstone* (Greek *mylos*); *to mill* (Greek *myllo,* Gothic *malan,* English *mill,* etc.); *meal* (Eng. *meal,* etc.); *mill-teeth* or grinders (Greek *mylitai,* Latin *molares,* etc.). The transition to the meaning of pounding and fighting will be easily understood after recalling that in English at this time we use milling in the sense of fighting (Greek *molon,* etc.); names of fighting deities (Sanscrit, *marut,* the storm, the smasher, Latin *Mars,* Greek *Ares*), whence *martial* and its relative words. From the aspect of wearing down or away came naturally to derivatives of the root the meaning of *decay, withering, feeble,* (Greek *marai'no,* to wear out, *maras'mos,* decay, *molys,* feeble, worn out, *molynomai,* to be worn out Sanscrit *murih,* to faint.) Hence, by an easy transition, the words ex-

pressing death and relative ideas (Latin *morior,* I die, *mortuus,* dead, *mors,* death, Greek *brotos,* mortal, *a'-mbrotoi,* immortal, *ambrosia,* etc., English *murder,* in addition to various words, such as *mortal* and *morbid,* coming by later borrowing). The root early gave rise among the Romans to words indicating the sea and its relations, the idea being that of dead water in contrast with living or running water, as we still use these expressions in English and French (Latin, *mare,* sea, etc., hence our *marine, maritime,* etc.). From the idea of grinding down came easily that of polishing, smoothing, (Latin *mulcere,* to strike, *mulgere,* to milk, Lituanian *milzti,* to stroke or to a milk, German *milchen,* English *to milk,* etc., of softening, soft (Greek *malakos* soft, hence our *Mollusc, moros,* foolish, Gothic *malsks,* foolish, English, *mellow, mild,* also *melt, smelt,* etc.; Lituanian for to love, Greek *meilisso,* to soothe, *meledaino,* to care for). Among many other meanings assumed in time by derivatives of mar may be mentioned grief (Greek *meledone*), to mourn, to brood over, (Greek *memairo*); to consider, revolve, remember (Latin *memorare,* to remember, etc.); from the idea of wearying away, the opposite, to forget; to brood over, to die for something (*martyr,* etc.); to hurt (*smart,* etc.; German, *Schmerz,* pain). But *mar* is only one of a large number of primitive roots any other of which

would show this same development to multiplicity and complexity.

Since any other family of languages yields to investigation results as to development in accord with the broad features of those now pointed out for the Indo-European family and convincing in proportion to the extent of the data studied, existing languages are clearly the result of an evolution conforming to the definition of the general theory previously enunciated. We have chosen the development of the languages of Indo-European family as a specific illustration of evolution precisely because of the thoroughness with which the main features have been demonstrated; and, futher, because not being open to reasonable doubt, we may also use with entire safety the materials for explaining analogous phenomena the biological field,—for making clear the meaning, not for argument as to fact.

To consider again evolution in biology, we may repeat that it is the theory according to which all plants and animals, all living things, are descended with continual variation and divergence from one or from but few original forms of life, in a way analogous to that in which the Indo-European languages have come into being by development along diverging and rediverging lines. Common errors as the theory are stated below.

1. The idea of development, or of a possible arrangement, of living things in a single series with what

might be regarded as the lowest form at one end and the highest at the other, like the links of a single chain, is wholly foreign to the doctrine. The biologist could no more think today of attempting,—could no more succeed in effecting—such linear arrangement of living things as should represent their real affinities than could the philologist succeed in arranging the languages of Europe and India, or of the whole world, in a single series in which the closely related should uniformily come together, and in which the most primitive should come first. Shall one place Spanish before Portuguese, or Italian before French; shall one place the Italic languages first or the Teutonic? Clearly neither arrangement would express the truth. The languages have developed along divergent lines. Now the facts in the biological field are precisely parallel. Furthermore, in the biological world one could no more rationably look for a "missing link," in the sense of a form intermediate between two other contemporaneous species, as so often popularly conceived, than in the philological we could look for a language half-way between French and German, or Italian and Modern Greek. These languages come together only in the distant past in tongues which were neither one nor the other, which were more generalized than either, but which possessed potentially the dialectic germs of both. Similarly, it would be quite impossible to place the cow in the ancestry of the horse or vice versa,

or to look upon either as having been in the ancestry of the monkey. Since each of these began to acquire its distinguishing characteristics, it has been diverging from all others. Living organisms, like existing modern languages, must diagrammatically be represented as the ultimate twigs in a repeatedly branching tree as shown in the accompanying diagram (fig. 2).

2. The theory is equally opposed to the even more wide-spread notion that it teaches a tendency in all lower plants and animals to develop toward humanity. Nothing is or can be more ridiculous to the sound biologist than this. On the contrary, it teaches that each form is developing farther and farther away from the common stock, becoming more and more peculiar and different from all other forms. Nothing could appear more absurd to a competent evolutionist than that any existing form of monkey or ape should become modified in the direction of humanity. The goal of evolution among monkeys has been clearly adaptation to the life of monkeys,—perfected monkey-hood,—as that of the horse can only be that,—by the geological records has been shown to have been in the past only that,—of perfect adaptation to the peculiar life of the horse. Similarly, the tendency in the cat family has been for them to become more feline. "There is no danger that the birthright of manhood will ever be taken from us by upstarts from below." These things should appear clearer after recalling the points indi-

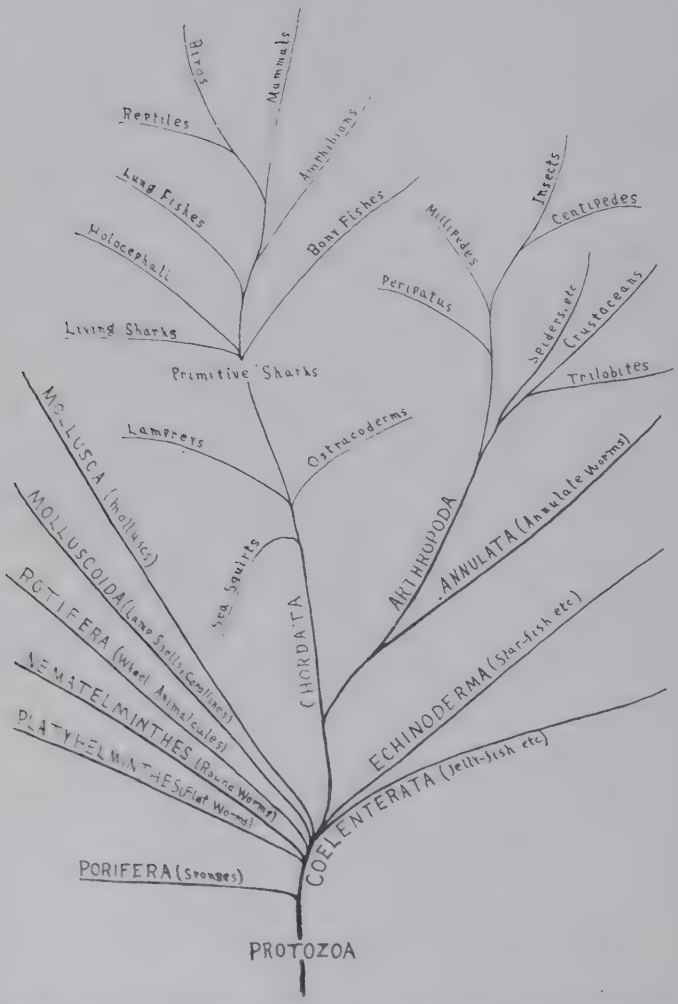


Fig. 2. Diagram representing approximate relationship and lines of descent of principal phyla or subkingdoms of animals. The primary divisions or classes of the Chordata and Arthopoda are also shown. Each other phylum would show similar branchings were its classes represented and, were the diagram further extended, each class would show branchings representing the orders, each order offshoots for the families and so on until the final branches or twigs would stand for species. Cf. fig. 1.

cated under 1. Directly connected with this misapprehension is one to the effect that evolution means necessarily relative progress. On the contrary, there are cases in which development has been clearly downward, regressive, as especially illustrated by forms that have taken to a parasitic life. Parasites frequently show the undoubtable loss of all or nearly all of the organs that might be called highest—such as organs of digestion, organs of sense and nervous system. But even in regression there is divergence contributing to the filling of the different possible conditions of existence. Regression does not consist in the retracing of ancestral steps—the goal appears still in the main adaptation to new fields.

3. Evolution in biology does not necessarily stipulate spontaneous generation or the origin of living matter from lifeless. All the positive scientific evidence is against such a notion. Among early peoples belief in such phenomena as the origin of mice from the mud of the Nile, and of insects from dew were prevalent; and even today popularly we meet with beliefs such as the turning of a dead horse-hair into a so-called hair-snake. All such beliefs are without any scientific basis. Evolution is consistent with any view as to the origin of the first life forms.

4. Evolution is not to be represented as in any sense a new force or as a real cause of anything; it is in no way a question of divine creation or of non-cre-

ation and, hence, is not the theological question so many suppose; it deals only with the method of creation, with the "secondary causes" of the process; it is the answer proposed by science to the question "how?" It is the description or formulation of a process. It is not a doctrine to be either affirmed or controverted by metaphysical speculation; but rests upon facts and phenomena primarily and legitimately open to the scientist.

5. The theory of evolution or descent is not equivalent to Darwinism or Natural Selection. Natural Selection is a particular theory to account for the controlling factors in evolution. From its first enunciation there have been firmly convinced evolutionists who rejected the explanation advocated by Darwin. Darwinism might be completely disproved without altering the status of the general theory of evolution in the slightest. It is in the same position with reference to the general doctrine as Lamarckism and other special hypotheses dealing with the factors involved in the process. Hence, people should not regard a "revolt" from Darwinism as in any sense whatsoever a revolt from evolution.

BIOLOGICAL PHENOMENA EXPLAINED BY EVOLUTION.

An inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it.—Huxley.

Prove all things; hold fast that which is good.—Paul.

Science cannot admit that any power on earth posesses the answer to her questions. Human knowledge is her only court of appeal.—D. S. Jordan.

The methods which intelligent people use in their every day lives in the acquisition of knowledge and in the formation of plans of action are essentially the same as those used in science. In both fields the faith of knowledge and reason rests in the reality of a material universe and in the constancy of its order; and we proceed upon the assumption that nothing happens excepting in its necessary order,—that nothing happens without a cause—and that the same result must invariably proceed from the same cause. In every-day life we reason only so far as we may be impelled through our grosser pains and pleasures to regard as

essential to our practical welfare; while in science we endeavor to carry the line of thought and reason to the utmost limits possible, our impulse being controlled by the higher ideals of perfection and completeness in knowledge. In science the methods are more refined, as those of the analytical chemist are than the rough approximations of the grocer; and, at the same time, they must be free from personal prejudice or bias and in the most rigorous accord with sound logic.

Knowledge, ordinary as well as scientific, is possible only when facts become grouped under hypotheses or theories, which are interpretations or reconstructions to thought of the ideas coming to us primarily through the senses. Science advances through the establishment of theories that prove adequate in experience, that accord with facts and express our conceptions in such a way as to enable us to predicate from known conditions what results will follow. Hence, speculation or the devising of hypothesis in science is of the very highest importance. It is by imagining a possible explanation of phenomena in a given field and then subjecting it to the test of observation and experiment that the scientist ultimately finds the truth or the interpretation that proves to accord with all the facts. Thus we see why "ferility of imagination and abundance of guesses at truth are among the first requisites of discovery; but the erroneous guesses must be many times as numerous as those which prove well

founded" (Jevons). For every hypothesis that stands the test of time and becomes a law, hundreds must be discarded as inadequate. The method of science is one of exhaustive trial.

This method involves four steps. The first is the gathering of carefully authenticated facts as a basis for generalization. The second consists in the search for some common relation between these facts, or for suggestions of such, which may be conceived and stated in the form of a general hypothesis. The third step involves the extension of the hypothesis by the methods of deductive logic to necessary conclusions concerning facts not yet observed. And the fourth step consists in rigorous observations and experimentation to determine whether these conclusions are right. It is the first and fourth of these steps that constitute the distinctive features of the scientific method of modern times. The other two were carried out as well, with a logic as strict, by the ancient Greeks and the early philosophers generally, as they are with us. The superior success of recent centuries in unravelling the secrets of Nature is due to the recognition of the supreme importance of accuracy in a review of facts for the foundation of the hypothesis and in particular of the testing of the theory after its conception by direct appeal to nature through observation and experiment to verify the issues of the hypothesis in its elaborated form. The view that the earth and other planets re-

volve about the sun was advanced as a supposition or hypothesis, as a scientific guess, to account for observed astronomical facts which the various earlier theories failed satisfactorily to explain. We accept this view as demonstrated truth without hesitation today because all the observations made since it was proposed fully accord with theoretical requirements, and because, accordingly, calculations or predictions made upon the basis of the theory are always fulfilled. Had any facts appeared which contradicted or were irreconcilable with the theory it must have been discarded like its predecessors.

If, then, the theory of organic evolution as previously defined is to be accepted as true or as demonstrated, it must meet very exacting requirements. In every division of the exceedingly complex living world, the facts must accord with the view or be explicable in its light. Probably no other scientific theory has anywhere nearly such a multitude and variety of facts to reconcile. In the present section it is the purpose to represent in some small degree the nature and direction of the testimony yielded in the different biological fields indicated by the headings which follow:

A.—THE CLASSIFICATION OF ORGANISMS.

In the world about us there exists a vast multitude of living things in which there appears to the ob-

server an almost unlimited variety. The individual living things are the realities to which the student must give attention primarily. While he finds that no two of these individuals are ever exactly alike, he notes that large numbers are so similar to each other that he may readily suppose them to have descended from the same ancestors and that they, furthermore, breed with each other and produce fertile descendants more or less closely resembling themselves. Each such group of similar individuals is today spoken of in science technically as a *species*. There are some millions of such species of organisms now living; while a much larger number have lived in the past and have become, in the course of time, extinct. Now it will appear clearly to any one who will give a little thought to the matter, that these species present very different degrees of apparent relationship to each other. The dog, coyote and wolf are clearly cousins, as it were, to each other and much closer together than they are to the cat or tiger or lion, just as the latter are closer to each other than they are to any one of the former species. For convenience each such group of more closely related species is termed a *genus*. Similarly the genera are found to present very different degrees of relationship to each other; and, hence, it is convenient to give a name to those which present the closer relationships to each other—*family*. Related families make up *orders*, related orders *classes*, and,

finally, related classes constitute *phyla,* the largest subdivisions of the plant and animal kingdoms.

Less close to the dog than the coyote and yet evidently not far removed are such forms as the foxes, which we accordingly place in different genera but keep close to the dog genus in the dog family. And so we find that bringing together the other more and more distantly related forms we finally get the whole class of mammals, or milk-giving animals, all the members, of which are united together by an endless chain of close relationship. And, in the same way, still further extending the process of bringing in forms showing obvious affinities, we should ultimately get together first all vertebrate animals and, then, finally, all living things in one great group which would show in all its different divisions the same close series of relationships and in the whole a succession of gradations in compelxity uniting together the simplest with the most complicated. Certain gaps appear, but these become fewer and fewer, and smaller and smaller as our knowledge of living and extinct species becomes more and more complete.

The arrangement which results from placing together in the manner indicated the most closely related forms is not, however, that of a single chain with the lowest form at one end and the highest at the other; but the disposition arrived at is such as may be represented by the twigs and branches of a tree, the end

twigs representing individuals, the groups of twigs species, groups of these genera and so on, until we arrive at the great branches arising immediately from the trunk and representing the phyla or sub-kingdoms. This is an arrangement precisely like that which alone can represent the relationships between the Indo- European languages, previously discussed, and precisely of the kind which everywhere exists among things known to have common descent or genetic affinity. (See fig. 2.)

In the European languages it was seen that the farther back in time we traced dialects the fewer they became, because of the repeated convergences, until finally we reached a single primitive tongue. Now it is found invariably among living things that the different groups, as for instance classes, are closer together at their lower ends, in their simplest representatives, than at their upper ends; that is, that as we go down from the highest representatives to the lowest the different classes tend to unite, as do the families and orders in each class and likewise the phyla themselves. (See fig. 2 and description.) As we go back in time, particularly, and study extinct forms we find the different lines to be brought more and more together until they frequently unite. In this way birds and reptiles run together and cannot be clearly separate any longer by definition and so in various other cases, where the gaps have been filled up, as all are becoming, through the

discovery of new living forms and especially of the fossil remains of ancient forms. As we go back in the scale, the groups become fewer and we come upon creatures of comparatively simple or generalized structure precisely as in the case of the languages. At the very bottom of the scale we find some very simple organisms which cannot definitely be regarded either as plants or as animals—they are as much one as the other. We see that even the familiar division of living things into plants and animals is an artificial one. There are no sharp division lines in living Nature. Our definitions of groups are possible only because of gaps in our knowledge. This thing is true even of the species of the systematist. As we become acquainted with more and more forms, what were regarded as distinct species are seen to run together through a complete series of intermediate forms, the result being that when a group is thoroughly known the number of species that may be defined is often less than at an earlier period. Species as ordinarily used, then, are largely arbitrary groupings of individuals as to which different workers are by no means necessarily agreed. The species of one may be only mere varieties to another. The story is told of a student of shells who kept his species from grading into each other by crushing intermediate specimens under his heel.

This unity of the living world manifested through a complete gradation from simple to complex through-

out all its branches, and the absence of natural lines of demarcation between groups is precisely what was to be expected on the theory of a common descent or evolution. Likewise the complex arrangement of organisms in groups within groups which approximate at the bottom of the scale and differ more widely at the top is clearly the arrangement which must result from true genetic relationship. No other source of such grouping is known. We see, then, that the facts arrived at through the study of systematic biology or the classification of organisms completely harmonize with and, thereby constitute strong evidence for, the theory of descent. On any other known hypothesis they are wholly without explanation or meaning.

B.—THE COMPARATIVE ANATOMY OF ORGANISMS.

On comparing in detail the structures of animals or plants belonging to the same class or other great group, it is found that there is the same fundamental plan of organization in all. Corresponding organs from such forms constitute series in which the same essential ground-structure prevails throughout, notwithstanding the organs in each series may be used for very different functions. A well known example of this is furnished by the arm or fore-leg in higher vertbrates. The fore-leg of the cat, the wing of the bat, the wing of the bird, the flipper of the whale, etc., have in their respective make-ups identically or almost

identically the same series of bones, muscles, blood-vessels, and nerves traceable more or less clearly. In the bird the fingers are short and run together, the expanse of the wing being due chiefly to the upper and fore-arm; in the bat the fingers are greatly elongated and over them is spread a membranous web, the limb being thus fitted for flight in a way quite different from that in the birds; even in the whale there may still be found the bones of shoulder, fore-arm, wrist and fingers notwithstanding all are enclosed in the fin-shaped sac which renders them useless except in swimming; and, similarly, in forms where the organ is put to still other uses, the same correspondence may be seen. Organs which thus obviously agree in fundamental structure are said to be homologous. No fact in science is more certain than the existence of homology throughout the living world. That it represents some deep and real law is wholly certain.

In every group of the plant and animal kingdoms we constantly meet with organs which are dwindled and obviously useless representatives of homolgous organs fully formed and highly functional in allied forms. In certain snakes, as the boa constrictors, are found imbedded in the posterior region of the body rundimentary hind limbs corresponding to the functional ones in such related forms as the lizards (see fig. 3); and the unborn whale has rudimentary teeth which never cut through the gums and so are never used (see fig. 5);

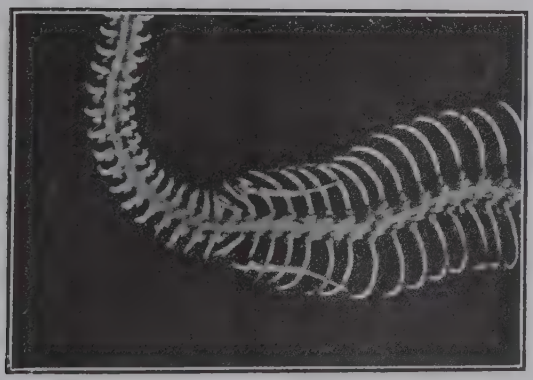


Fig. 3. Part of the skeleton of a snake (boa constrictor) showing vestigial bones of the hind limbs.

Fig. 4. Skeleton of Greenland whale showing vestigial pelvic bones near the base of the tail.

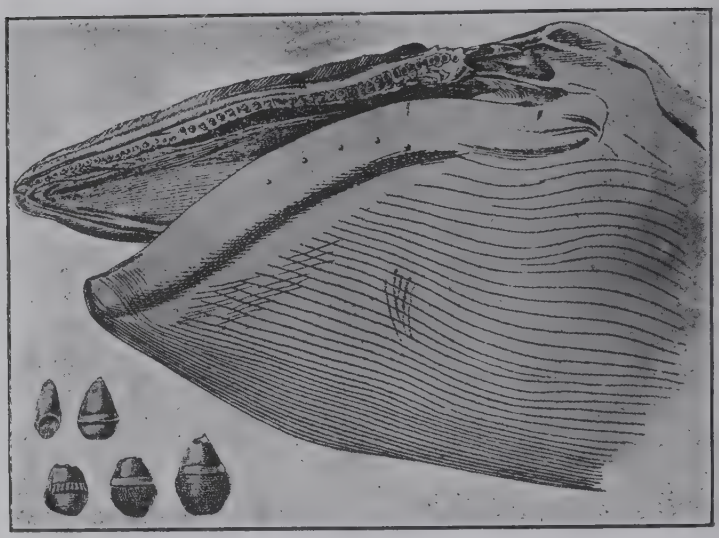


Fig. 5. Jaws of an embro whale with part of gums removed to show the rudimentary teeth which normally are never "cut." Some of these teeth on a larger scale are shown below at the left.

many cave animals living in total darkness possess eyes in the condition of mere rudiments which never function; in fact, rudimentary organs of this kind are so very common that there are few species not possessing one or more of them, the bodies of some higher forms, such as man, being crowded with them.

Of the numerous rudimentary organs occurring in man may be mentioned the third eye-lid or nictitating membrane. In various lower forms, such as the cat, etc., reptiles, and birds, this eyelid may be moved independently of the others quite across the eyeball; but in us the membrane is vestigial and wholly immov-

able (see fig. 6). The muscles which in lower forms are used to move the ear are in the great majority of human beings rudimentary and quite functionless. In the ears of many persons, also, there is indicated a point turned inward on the lobe which is the representative of the tip of the ear, present in most animals (see fig. 8). The coccyx bone in man is composed of a number of consolidated vertebrae and, with associated parts, represents in vestigial condition the tail of lower forms. It frequently happens that muscles fully corresponding in position and attachments to those useful in tailed animals in moving the tail are present in man in rudimentary condition although evidently now wholly functionless (see fig. 7). The muscles which in lower animals move the skin are in most persons too weakly developed to do so. The vermiform appendix is the vestigial representative of the very long coecum or blind sac present in low mammalian types, such as the kangaroo (see fig. 9 and description). The hair of the body is in vestigial condition. And so the list might be extended to almost two hundred such organs in our bodies.

Another set of facts pertinent here deal with the phenomenon of the appearance in a species in a more or less well developed condition of organs and structures not normally present, but which are present in related living species or in extinct forms. In the horse, as will be explained in another place, but one toe is

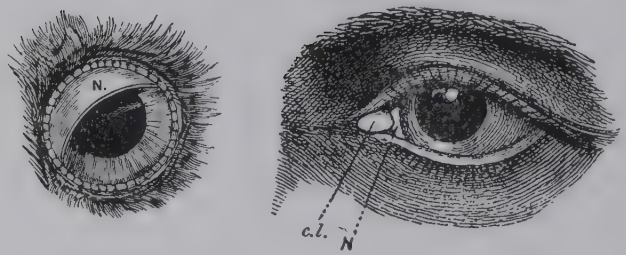


Fig. 6. At the left, the eye of an owl, showing at N the large and independently movable third eye-lid or nictitating membrane. At the right, the eye of a man showing the nictitating membrane, N, in vestigial condition.

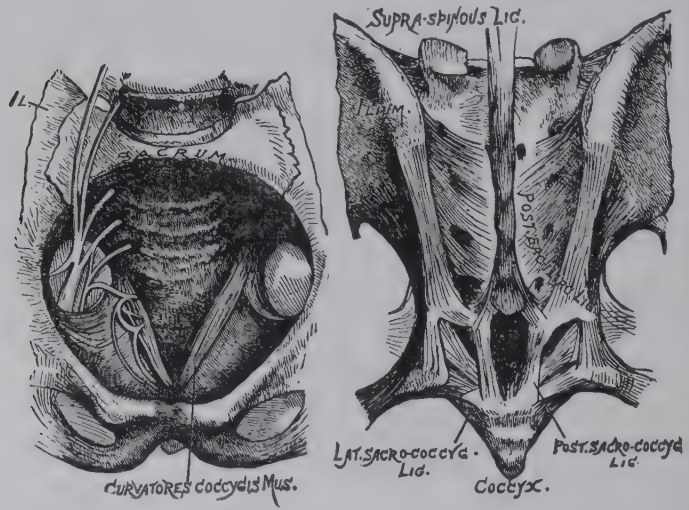


Fig. 7. Front and back view of the human sacrum, etc., showing at the right the coccyx or vestigial tail and especially in the left figure tail muscles, abnormally persisting, in vestigial condition.

normally developed on each foot, although two others are represented as vestiges, one occuring on each side just below what is ordinarily spoken of as the knee but what is really the wrist or ankle. These rudiments are known as splint bones. Now cases are known of colts in which these splint bones did not remain rudimentary but developed and bore hoofs precisely like those which were normally present in the extinct horse regarded as the ancestor of the living one, as explained later. A phenomenon of this kind is known as atavism or reversion. Many such cases are known both among animals and plants.

In man, the tail, instead of remaining rudimentary and not extending visibly, sometimes reverts to the more primitive conditions and is detected as an external appendage, having vertebrae, muscles, nerves and blood vessels homologous with those present and functioning in the tails of lower related forms. In fact, reappearances of this kind among the muscles, bones, and other parts and organs of the body are so frequently met with that, in connection with the other facts previously suggested, they must continually cause the anatomist to exclaim in effect with Broca, "Anatomy, like that slave who followed the triumphal car, repeating the words *'memento te hominem esse,'* comes to agitate man in his self-admiration, and reminds him that reality, visible and tangible, links him with the animals."

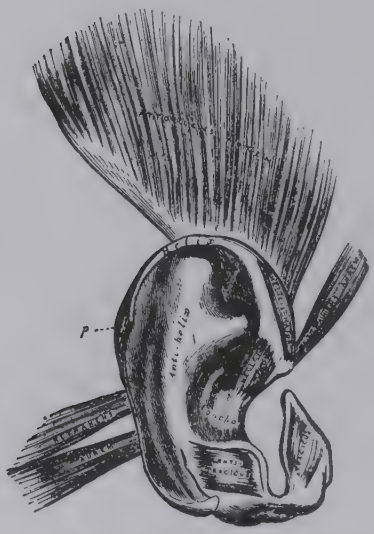
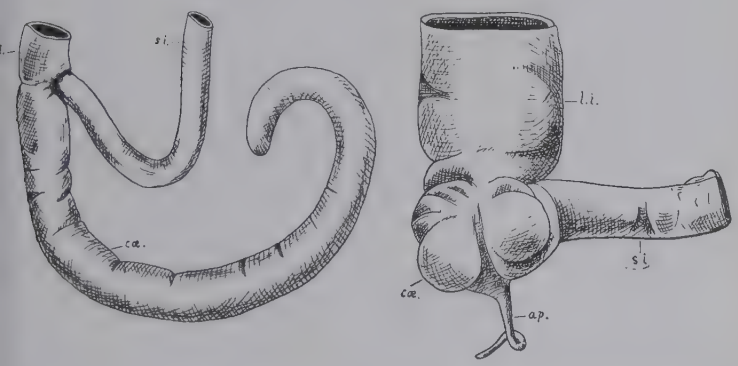


Fig. 8. Muscles of the human ear, which are rudimentary and, in most persons, functionless. Likewise, many muscles used in lower forms to move the skin over various parts of the body, in man are vestigial and without such function. At t is shown the vestigial ear-tip turned inward. It is present in many individuals.

Things which are so widespread cannot be due to chance; they must have some common underlying reason. What is the meaning of these rudiments and what is the meaning of the other facts of homology? Evolution presents a very simple explanation, the facts being precisely what, in its light, were to be expected, while no reasonable alternative explanation has ever been suggested. On the supposition of evolution, *homology is obviously the stamp of a common heredity, indicative of real blood relationship.* When animals



ig. 9. At left, the coecum, coe, of the kangaroo, showing the elongated condition prevalent in primitive types of mammals. At the right, the same part of the intestine of man, showing the terminal portion of the coecum reduced to the rudimentary vermiform appendix, ap. In both figures, s. i. indicates the small intestine, coe the coecum and l. i. the colon or large intestine.

descended from a given ancestor have assumed other modes of life, any organ or organs no longer of service would gradually dwindle through disuse; but heredity, with its well-known persistence, would still long preserve the reduced and unused organ as a rudiment and occasionally bring the organ out in fully developed condition as an atavism. Finally, the organ might cease to appear even as a rudiment.

In the case of languages we saw that what closely related dialects or tongues have in common is due to tradition from the same original speech. In precisely the same way, according to evolution, what animals have in common is due to heredity from a common ancestor and the more recent their divergence from the same stock the greater the extent of their correspon-

dence in structure and other features. In languages it was seen that words, phrazes and grammatical devices often tend to pass out of use and finally to become obsolete or even wholly lost. Such words and expressions may be compared to organs and functions, in animals which on similarly becoming useless dwindle to rudiments or disappear completely.

Additional illustration of these facts may be given by further reference to the whale, the ordinary whalebone form serving our purpose. The nearest relatives of the whales are four-legged, hair covered, milk-giving land animals of the class of mammals. In internal structure the whale notwithstanding its differences in habit or environment, preserves closely the characteristic features of such animals. In outer characteristics, it shows modifications fitting it to continued life in water. The body has taken on a spindle shape similar to that of the fish and a strong horizontal tail-fin has been formed for the purpose of propulsion. The hind limbs being of no service have become mere rudiments represented by a chain of bones imbedded in the pelvic region (see fig. 4). The forelimbs, on the contrary, as before mentioned, have become modified into strong flippers which aid in swimming, but which, nevertheless, in ground plan still reveal the parts present in the ordinary walking limbs of related land forms. The head and mouth have become greatly enlarged but agree closely in details of structure otherwise

with the typical mammalian form, this huge enlargement of mouth and jaws, aided by the fringe of whalebone developed along the edge, enabling the animal to strain out from the water great quantities of the simple organisms which serve it as food. The teeth have correspondingly becoming rudimentary and never cut the gums, as before explained. The external openings of the nostrils have become shifted to the top of the head so that the whale can still breathe when almost completely submerged; while the larynx has become modified in such a way that breathing does not interfere with swallowing. External ears have disappeared. Hair has almost completely disappeared from the body of the adult, warmth being furnished by a thick layer of blubber developed under the skin, this blubber serving further to lend buoyancy to the body. But, great though the modification from the type form of mammals is in the whale, adapting it closely to its peculiar mode of life, we see that homologies clearly exist between its different organs and parts and corresponding ones in more typical land mammals and that, when considered in connection with the latter, its rudimentary structures take on an obvious significance.

C.—THE DEVELOPMENT OR EMBRYOLOGY OF ORGANISMS.

It is now a well-known fact that every one of the higher plants and animals normally takes its beginning

in and is evolved or developed from an apparently simple particle of living substance in which no trace of the distinctive characters of the adult are discernible,—the germ or germ-cell. The germ-cells of all organisms at the outset are very much alike in observable features. As development proceeds, each germ acquires, first the differential features of the subkingdom to which it belongs, then successively those of its class, order, family, genus, species and variety or race and last of all, the individual characteristics. Thus two animals belonging to the same family but to different genera will in their earlier stages be essentially alike and will begin to diverge only after the features of the family have been acquired. So lizard and sparrow and frog and rabbit, and man, although these forms can be distinguished by the special student, present closely corresponding structures for a considerable length of time after the beginning of development (see fig. 11). Nervous system, circulatory system, and so on, are the same in essential form and arrangement. Later on the features distinguishing the classes to which these forms respectively belong appear and divergence sets in. Thus organisms are always closer together in their early stages of development than in the adult condition, in which they always come to the maximum degree of separation.

But the development of the individual is not commonly as direct as might possibly be thought from the

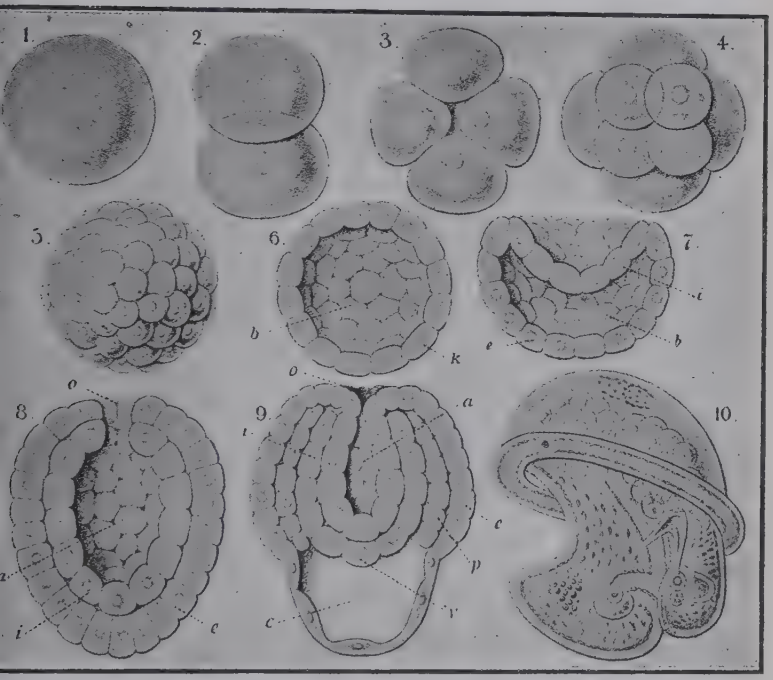


Fig. 10. Early stages in the development of the pond snail, showing successively the development through cell division from the one-celled stage or simple ovum to the many-celled blastula stage, in which the cells are arranged in the form of a hollow sphere surrounding a central cavity, and then to the gastrula, or stage in which by invagination of the blastula, the embryo has come to consist of two layers of cells surrounding the primitive digestive cavity which has a single opening to the exterior. The gastrula is a stage through which all higher many-celled animals pass and corresponds broadly to the permanent adult condition in certain low relatives of the jelly-fish. The last figures show the immediately succeeding stages in the evolution of the individual snail.

preceding statement of the order in which characters appear. On the contrary, the development is quite commonly indirect. Organs frequently appear like those possessed by adults of related forms but having no function in the species under consideration and hence af-

Fig. 11. Vertebrate embryos at three comparable and progressively later stages of development. Observe their close similarity in these early stages. In stages I. and II. note the gill slits, limb buds, distinct and relatively large tail, etc., the latter in man later normally aborting and remaining in the adult as the vestigial coccyx and associated parts.

ter a while becoming wholly obliterated, reduced to rudiments, or modified into quite different structures by the time the adult condition is reached. The black salamander of Europe, unlike its relatives, does not lay its eggs in the water and the young therefore never normally swim in the tadpole stage and thus have use for gills. Yet, though the eggs are retained normally in the female until after the tadpole stage, all the young of this stage possess well-developed gills which may be used if the young are artificially transferred to water. Why should gills be perfectly developed although never used? While gill fillaments are not developed, nevertheless, even in higher vertebrates such as birds and mammas, including man, gill-slits like those of the fish are uniformly developed through the sides of the throat and at this stage (see figs. 12 and 13), the whole circulation is like that of a low shark-like fish. The homologies are undoubted. Later the gill-slits close and the circulation becomes modified into the adult form. The nervous system of a mammal is at first like that which is the permanent condition in the lower fishes, then is takes on the features of the nervous system of the amphibian and lastly takes on the features distinctive of mammals. And so also, no matter what system or organ or part of organ we study, we shall find the same phenomenon, the part passing through stages which are permanent in lower related forms before attaining the condition characteristic of the species under

Fig. 12. Human embryo of from 20 to 25 days development, showing at G, the gill-slits; at T, the tail; and at Ys, the vestigial yolk-sac, etc. Am is the amnion, a membrane enclosing the embryo. The yolk-sac is

consideration. Everywhere it is apparent that, within the limits of each great type of organization, the higher forms develop from the originally simple germ in such a manner as to pass in essentials through the permanent conditions of the low forms as transitory stages.

What is the significance of these embryological facts? Why should the young mammal get kidneys similar to those of the lowest fish-like creatures, then replace these by such as the adult frog possesses, which in turn degenerate, and then finally develop a wholly new third set? The lowest mammals, such as the duck-bill or ornithorhynchus of Australia, lay eggs which contain much yolk, like those of birds. In developing, the eggs acquire yolk sacs in which the food yolk is contained until used by the growing animal, just as in the case of the chick. Higher mammals retain the eggs in the body until development is complete and nourish the young by direct transfusion of parental blood. The yolk has accordingly entirely disappeared from such eggs. Why should the yolk sac, nevertheless, be still clearly developed although never holding yolk? (See fig. 12 and explanation). Speaking more generally, why is it that a mammal begins to develop as though it were going to become a fish, then chang-

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reminiscent of the condition in the lowest or most primitive mammals which lay large eggs like those of reptiles and birds, the yolk of all which becomes enclosed in a yolk-sac where it is drawn upon for the nourishment of the developing embryo. In most living mammals the developing young are retained and nourished within the body of mother and yolk is accordingly no longer deposited within the eggs; but heredity still conserves the yolk-sac, though now wholly functionless, as one of the numerous "pensioners" retained for past services.

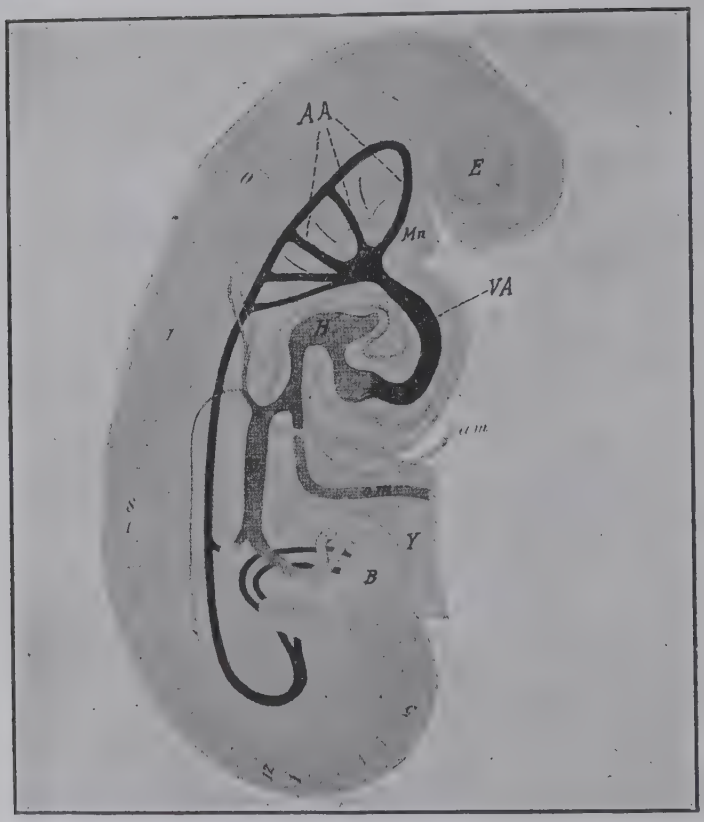

Fig. 13. Reconstruction of a human embryo about the same age as that represented in figure 12 (20 to 25 days, 2.6 mm. in length), showing the fish-like circulatory system. The main arterial vessels solid black. Note the simple heart (H) from which runs forward the ventral aorta (VA). This gives off, as in the adult fish, 5 pairs of aortic arches (AA) which run between the gill slits and again unite in the dorsal aortae. The main venous vessels also correspond closely to those of typical fishes.

ing its course, develop further as though it were going to become an amphibian or reptile, and only after

much delay begin to assume the distinctive characteristics of mammals, as though an architect who was going to build a palace should first use the materials in building a hut, then pulling it down should use the materials in rebuilding a cottage, "adding room to room and story to story, not with any reference to the purposes of the palace, but wholly with reference to the way in which houses were constructed in ancient times?" And so we might go on with questions upon an almost limitless number of similar facts.

In the light of the theory of descent, all these numerous facts of embryology have a very simple explanation, while they are without meaning on any other assumption. According to evolution individuals through the force of heredity preserve in their development orderly traces of their pedigrees and the developmental history of the individual is thus an epitome of the history of that branch of the animal kingdom in which it culminates. Every individual lives over again the life of its race; this is the principle of "recapitulation." Higher mammals in their development show a yolk-sac because they are descended from egg-laying forms in which the sac was functional and the structure comes out still as a simple matter of heredity; gill-slits develop in mammals, birds, and reptiles as well as in lower vertebrates because the common ancestral forms of all vertebrates were aquatic, fish-like creatures and heredity preserves record of the fact. In general the char-

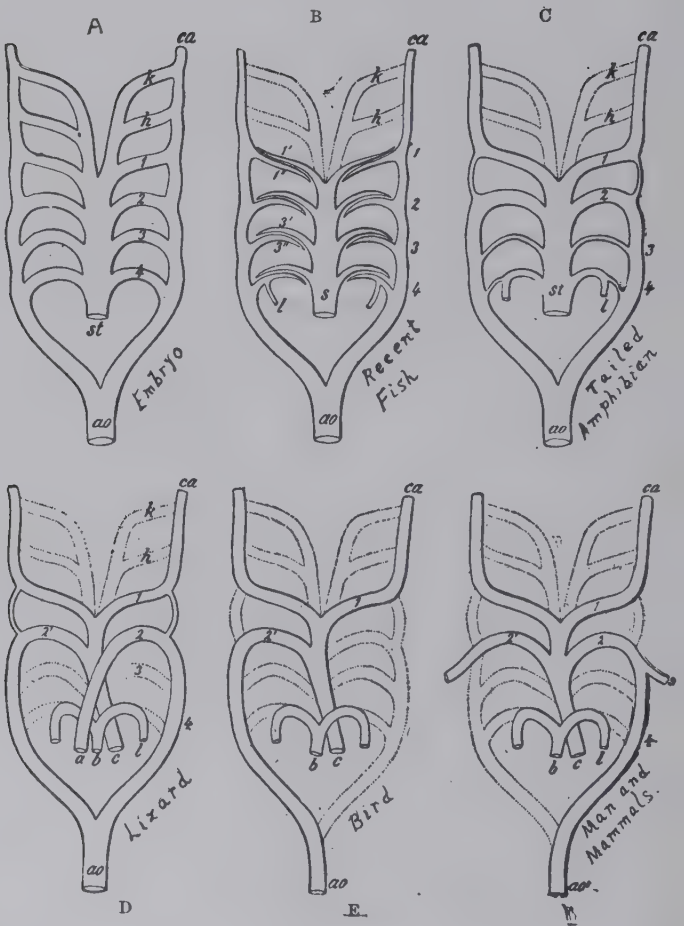

Fig. 14. Diagrams showing the divergent ways in which the embryonic aortic arches, corresponding to those of adults among primitive fishes, are modified in the adults of different types of vertebrates. The vessels which disappear as such in the course of embryonal development are outlined with dotted lines. The vessels which persist are drawn with heavier, continuous lines.

acters develop in the order in which they were acquired in the race. It must be understood that the record is much abbreviated and has frequent gaps, as must naturally be expected, and also that the parallelism between life history and history of the race in time is general and not special. This principle has proved of inestimable value in unravelling the relationship of animals of doubtful position. Thus, the degenerate, shell covered, sessille barnacles were long an enigma. Cuvier placed them near the oyster. But their development shows an early free-swimming stage in which the whole structure is that of a crustacean; and, in the light of this fact, we can easily trace out the features in the degenerate adult as modifications of the crustacean type. And so in many other cases the ancestry and relatives have been clearly indicated by the development.

It requires the special training of the biological laboratory fully to appreciate the wealth of evidence supporting the idea of descent to be drawn from embryology. Thousands of facts in this field are explained with clearness and brought into harmony with findings in other branches of biology upon this assumption which have no adequate explanation otherwise. The general argument from embryology seems very strong, even when taken alone, in favor of descent when the full extent and force of the facts are appreciated. Though some have worked the principle

of recapitulation beyond legitimacy in some cases, the reality of the law is beyond question.

D.—GEOGRAPHICAL DISTRIBUTION OF ORGANISMS.

It will readily be seen that the distribution which organisms have over the earth should afford very important evidence upon the theory of descent; for as this theory implies the gradual origin in time of one species from the descendants of another, and likewise of the still slower formation of genera, families and orders, we should logically expect that the plants and animals inhabiting any particular region would be found to resemble or differ from those of any other section according to whether barriers to the spreading of living things between the two areas were slight or great. Species or genera, or families originating in a given country would spread only to such other sections as they had had opportunity of reaching by their ordinary means of migrating. The faunas and floras of two countries should differ in proportion to the extent or effectiveness of the barriers between them and to the length of time and constancy with which such barriers have existed, and, to a considerable extent, irrespective of the relative fitness of the countries for maintaining the different forms.

Proceeding now to the facts, we find that observation everywhere shows that the most closely allied creatures commonly live in adjacent and easily ac-

cessible districts and that, when any considerable barrier, such as an ocean or high mountain range, is passed, the fauna and flora nearly always become entirely different. "Barriers of any kind, or obstacles to free migration, are related in a close and important manner to the differences between the productions of various regions. We see this in the great difference in nearly all the terrestrial productions of the New and Old worlds, excepting in the northern parts where the land almost joins (and at times has actually joined). * * * * We see the same fact in the great difference between the inhabitants of Australia, Africa, and South America under the same latitude, for these countries are almost as much isolated from each other as possible. On each continent, also, we see the same fact; for on the opposite sides of lofty and continuous mountain ranges, of great deserts, and even of large rivers, we find different productions; though as mountain chains, deserts, etc., are not so impassable, or likely to have endured so long, as the oceans separating continents, the differences are very inferior in degree to those characteristic of distinct continents." The differences in the former case are usually confined to species and genera while in the case of different continents the differences often extend to families and orders.

In South America, the climatic conditions on opposite sides of the Andes Mountains differ but little; how-

ever, these mountains are very high and difficult to cross. On the other hand, the differences between the conditions on the north and south sides of the Caucasus Mountains are very great. Now we find, nevertheless, that the fauna and flora separated by the Andes Mountains are much more unlike than those separated by the Caucasus because the latter are so much more readily crossed than the former. The conditions of the waters on opposite sides of the isthmus of Panama are almost identical; yet the respective faunas of the Atlantic and Pacific sides are almost totally different, but few forms being common to the two, the few miles of land making up the isthmus constituting a barrier impassable to marine forms. A classic exemple is furnished by the Galapagos islands. These islands are situated about six hundred miles west of the nearest part of South America. Excepting some kinds of birds which are strong flyers, and a few other forms, the fauna is distinct, so far as genera and species are concerned, from all others. Yet the fauna is distinctly South American in type and is most closely related to that of Chili, the nearest part of the mainland. On comparing, furthermore, the animals living on the different islands of the mainland, we find varietal and specific differences along with generic agreement. Relations of this same kind are found universally between the plants and animals inhabiting oceanic islands and those of the nearest continents. Furthermore, the forms found upon the isl-

ands, excepting where these are close and have evidently had land connection with the mainland, are such and such only as could in some way, whether through accident and conceivably only at long intervals, or otherwise and more frequently, have crossed the intervening water. Hence, we find on such islands naturally a complete absence of all large land animals and also of such forms as toads and frogs, which, together with their eggs, are known to be immediately killed by sea-water and so could not be carried by currents on logs or other floating material. These forms are absent only because they could not reach the islands, for the conditions upon the islands are often peculiarly favorable for their existence. This is shown in the case of toads and frogs which since their introduction by man into Madeira, the Azores and Mauritius, have multiplied to such an extent as to have become a nuisance. Many illustrations might be given to show the truth of the conclusion here involved, that organisms do not occur in all places fitted for their existence or even necessarily in those for which they are best adapted; but only in regions into which they could spread by natural means from the one in which they took their origin. In Australia originally there were no rabbits; but the rabbits, since their introduction by men, have thrived so well as to have overrun the entire country as a serious pest. Watercress carried from England to New Zealand exhibits greater vigor and fitness in the streams of its new

home than ever in those of its native land. As every one knows, the English sparrow has done all too well in America; while nearly all of our so-called weeds in this country, which maintain themselves with well-known facility, are likewise importations from Europe.

The evidence yielded from the study of the geographical distribution of organisms is seen thus to accord with the expectations of the theory of descent in the fullest and most detailed way. An overwhelming mass of facts in this field on the assumption of the theory receive clear explanation and become resolved into a simple and harmonious system which on any other hypothesis yet conceived are wholly inexplicable.

E. GEOLOGICAL SUCCESSION OF ORGANISMS.

It has been thoroughly established that the stratified rocks of the earth's surface have resulted from the consolidation of sedimentary deposits laid down in the lakes and oceans of earlier times. What the relative ages of the different deposits are has for the most part been clearly demonstrated. Since vast numbers of animals which became imbedded in the different deposits have been preserved in the form of fossils, it is evident that thorough study of these geological records in different countries should give us important testimony as to successive changes in the general character of plants and animals on the earth from the earliest times down

to the present. This testimony should furnish crucial evidence upon the theory of evolution.

A study of the geological strata in the order of their age shows that the first organisms upon the earth were of very simple kinds and that, as we proceed upward through the strata, fossils of successively higher and higher forms appear, leading finally to the remains in the more recent rocks of forms similar to those now living. (Consult the accompanying table.) Right here we may see that the facts of geological distribution must be in complete harmony with those of geographical distribution if evolution is a fact, while on any other known hypothesis there is no reason whatsoever why any such harmony should exist. That there is, in truth, close agreement between the facts of geographical and those of geological distribution may be abundantly shown. It is a striking fact that the later fossil species found on the different continents invariably possess the distinctive characteristics of species still living in the same regions or in regions to which migration is or has been at some intervening time, possible. The fossil mammals found in Australia are chiefly marsupials allied to those which now inhabit the continent; while the fossil mammals recovered from deposits in South America are close allies of the peculiar sloths, ant-eaters and armadillos living in the region at this time. And so it is in all cases where our knowledge of geological facts is moderately

TABLE OF GEOLOGICAL DIVISIONS SHOWING SOME CHARACTERISTIC ANIMALS OF EACH.

ERA	PERIOD	MORE CHARACTERISTIC ANIMALS
Cenozoic Era of Mammals	Quaternary or Pleistocene	Man; mammals chiefly of living species. Mollusca exclusively recent.
	Tertiary: Pliocene	Mammalia principally of recent genera, a few of living species. Mollusca modern.
	Tertiary: Miocene	Mammalia mostly of living families, numerous extinct genera and all species extinct. Mollusca in part of recent species.
	Tertiary: Eocene	Mammalia: Numerous orders and families most genera and all species extinct. Mollusca of modern types.
Mesozoic Era of Reptiles	Cretaceous	Flying reptiles. (pterodactyls); dinosaur reptiles; First Snakes. Toothed birds. Bony fishes and Sharks abundant.
	Jurassic	First birds. Giant reptiles (ichthyosaurs, dinosaurs, pterodactyls) Ammonites. Clams aud Snails abundant. Brachiopods decline.
	Triassic	First mammal (a marsupial.) Two-gilled cephalopods. Sharks reduced. First bony fishes.
Paleozoic Era of Invertebrates	Carboniferous (Age of Amphibians)	Earliest true reptiles. Amphibians. Lung-fishes. First Cray-fish. Insects abundant. Centipedes. Spiders. Extinction of trilobites.
	Devonian (Age of Fishes)	First amphibians. Sharks and ganoid fishes. First land and fresh water shells (snails, etc.) Mollusca abundant. Crabs. Trilobites decline.
	Silurian (Age of Invertebrates)	First terrestrial or air-breathing animals. (insect; scorpion.) Corals. Graptolites. Trilobites. 4-gilled cephalopods. Armored fishes.
	Ordovician	Earliest fish (ostracophores, with armor and cartilaginous skeletons.) Brachiopods. Mollusca. Trilobites, etc.
	Cambrian	Invertebrates only. Sponges. Jelly-fish. Annulate worms. Mollusca. Brachiopods. Echinoderms. Polyzoa.

full,—we find the fossil forms distributed precisely as they must be if they were the progenitors of their most nearly related successors.

In some cases, fortunately, where the geological record is approximately complete, we have preserved a long chain of consecutively related types leading back from living species to remote and very different forms. In Slavonia there are certain fresh-water lakes which geologists ascertain have been drying up with extreme slowness for thousands of years, even from what is termed the tertiary period. During all this time the water has been inhabited by snails of which the most ancient were apparently the progenitors of their immediate successors and so on down to the present. From age to age the shells of the snails have fallen to the bottom to be covered up with mud and sediment and thus to be preserved in fossil form. As the sediment has been steadily accumulating year after year and century after century, it is evident that by digging or boring down to the lowest level and obtaining shells from it and also from successively higher and higher levels we should obtain a clear record of any changes that may have taken place in the snail shells. This has been done, with the result that the shells from the oldest deposit are found strikingly different from the recent form but are at the same time found connected with the latter by a complete series of closely intergrading forms. Five or six species were constituted

Fig. 15. Transmutations of Paludina from fresh-water tertiary deposits in Slavonia. At 1 is shown the type found in the lowest strata, those appearing in successively later and later strata being indicated by the figures from 2 to 17.

from these shells until the connecting or intermediate forms found were so numerous that distinctions between the suposed species could no longer be maintained. Shells arranged in the order of succession show the progressive modifications represented in the accompanying figure (fig. 15). In similar cases of

other shells not only different species but clearly different genera may be traced in their seeming formation from a single original type.

One of the most instructive and best known cases of this kind is in the series of fossil horses and horse-like creatures which have been found in particular abundance in fossil beds of our own country. The series runs back to a very remote form a little larger than a medium sized dog and having four separate toes on each forefoot and three on each hind one. Next later we find an animal larger and with only three toes on the forefeet, the fourth, however, being represented by a dwindled rudiment. Next in order appears a form in which the rudiment of the fourth toe has disappeared and the two lateral of the three remaining toes on each foot show reduction, the middle toe correspondingly having an increased size. This form is succeeded by one like itself about the size of an ass. It has the two side toes reduced to mere splints. Finally appeared species of the same genus as the modern horse and closely resembling it. In the horse proper (Equus) the middle toe has become larger and the splint bones more reduced but still present and evidencing the three-toed ancestral condition. Similar progressive changes are evident in the teeth and other features of the skeleton as in part represented in the accompanying figure (fig. 16). We now have evidence of the parallel development of several races

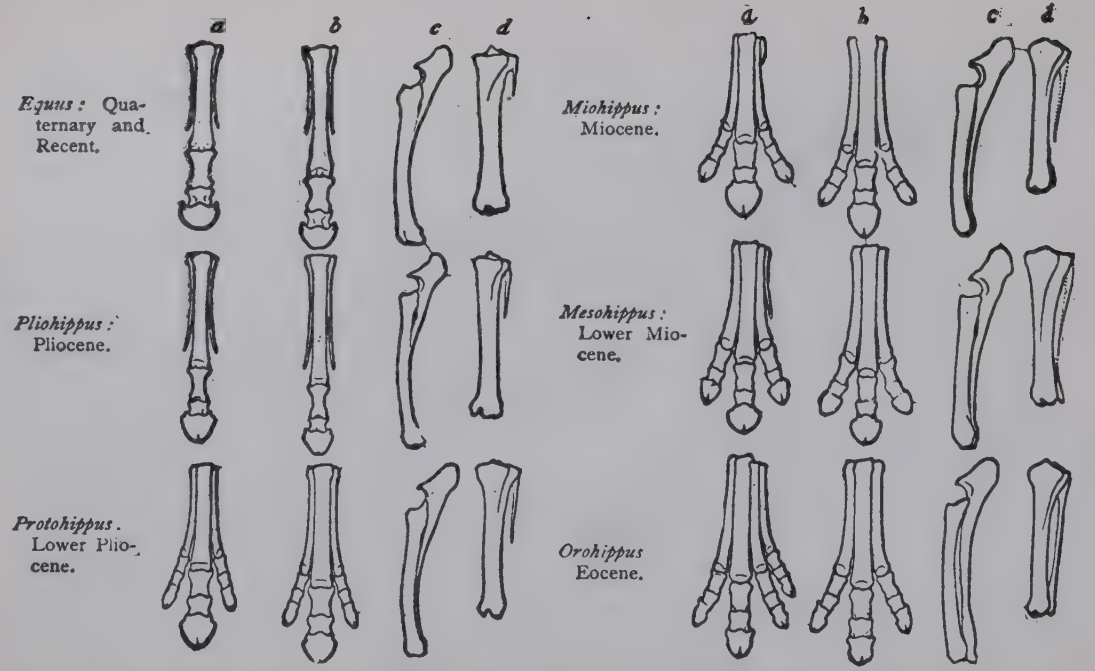

Fig. 16. Drawings showing successive changes in foot and leg bones in fossil and recent species of the horse family. a. Bones of the fore foot. b. Bones of the hind foot. c. Bones of the fore arm or lower front leg (radius and ulna). d. Bones of the lower hind leg (tibia and ulna). Note especially the gradual reduction of the lateral toes from the early functional condition to mere vestiges ("splint bones") in the modern horse. Note likewise changes in bones of lower fore and hind legs.

of horse-like creatures, not yet distinguished at the time these figures were originally prepared by Prof. Marsh.

It appears, then, that the general distribution of organisms through the geological strata, where facts are reasonably abundant, agrees fully and in a most remarkable way with what was to be expected on the theory of evolution. The origin, increase, distribution, decline and final change or disappearance of organic types with the progress of geological history as we find them are exactly what the theory demands and are on any other enigmatical. All we know of the history of the past life on the earth accords with the theory of descent, and ever more and more fully supports it as the knowledge becomes more and more complete. In many cases, furthermore, such as those explained above, the evolution of existing forms from forms preceding them in time is as clearly a matter of history and of demonstration as, in the nature of paleontological evidence, is possible.

F.—THE OBSERVED CHANGES IN LIVING ORGANISMS.

Philologists have shown, as was brought out in the previous chapter, that the many different languages of the Indo-European family can be fully accounted for as derivatives of descendants from a single original tongue upon the assumption that processes of change which are every where operating in them at this time,

Fig. 17. An extinct and primitive bird, Archaeopteryx; restored. Example of an annectant or connecting form. Note, among other reptilian characters evident, the long lizard-like tail along the sides of which feathers are arranged, a pair to each vertebra, and the presence of teeth in the jaws. Observe the free fingers ending in claws which in living birds are absent or reduced to mere rudiments.

or which can be shown from sufficient records to have operated within historical times, have been operative continuously in like manner in the past. In an analagous way evidence as to the nature and degree of

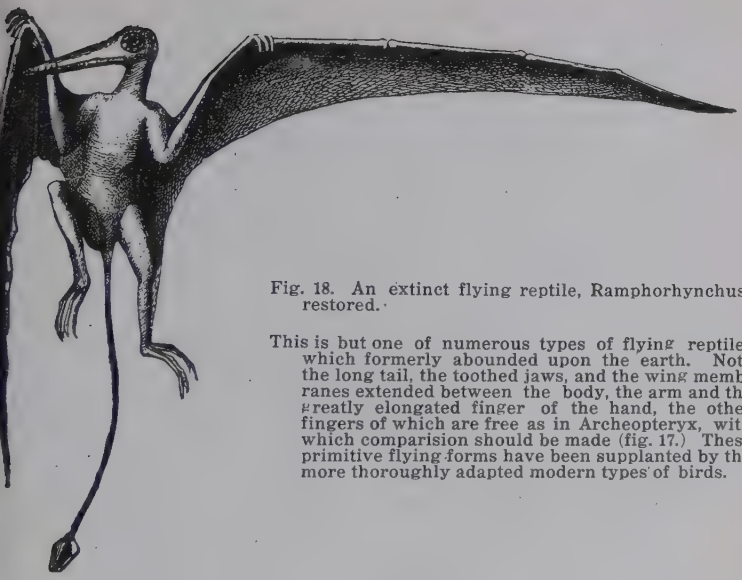

Fig. 18. An extinct flying reptile, Ramphorhynchus; restored.

This is but one of numerous types of flying reptiles which formerly abounded upon the earth. Note the long tail, the toothed jaws, and the wing membranes extended between the body, the arm and the greatly elongated finger of the hand, the other fingers of which are free as in Archeopteryx, with which comparision should be made (fig. 17.) These primitive flying forms have been supplanted by the more thoroughly adapted modern types of birds.

change taking place at present or within historical times in living organisms must be regarded as of the highest importance in its bearing upon the theory of descent. If the theory is true, then what might reasonably be expected in this field is the occurrence of changes of such kind and extent as would, if continued through a requisite space of time, suffice to bring about all the diversity and multiplicity found in the animal and plant kingdoms.

That considerable changes do, in fact, occur in plants and animals observed continuously under domes-

tication will appear to every one upon recalling how many new varieties are yearly placed upon the market by breeders and fanciers. A notable example is afforded by the numerous breeds of pigeons which are known to have originated since domestication from a single wild species or from closely allied varieties of the same. Pouters, fantails, carriers tumblers, and all the rest have the same ancestry (see fig. 19). Similar examples among other animals are common. In one section of South America a new and constant species of cat has developed from the domestic cat of Europe. Not only do new forms originate through the accumulation of small variations brought about by long selective breeding in this way; but sometimes forms are born which, from the very first, are widely different from the parents and which, when bred so as to avoid intermixture, preserve their distinctive characteristics indefinitely and without any tendency to revert to the parental type.

Among plants we find abundant illustration of similar facts. That we cannot surely identify the wild species from which a hundred or more cultivated plants came originally is evidence of the changes they have undergone since they were first taken into cultivation. Such are the melon, pumpkin, sweet potato, chrysanthemum, orange, peach, plum, and apple. The accompanying figure (fig. 20) shows a few of the strikingly different kinds of vegetables that have been

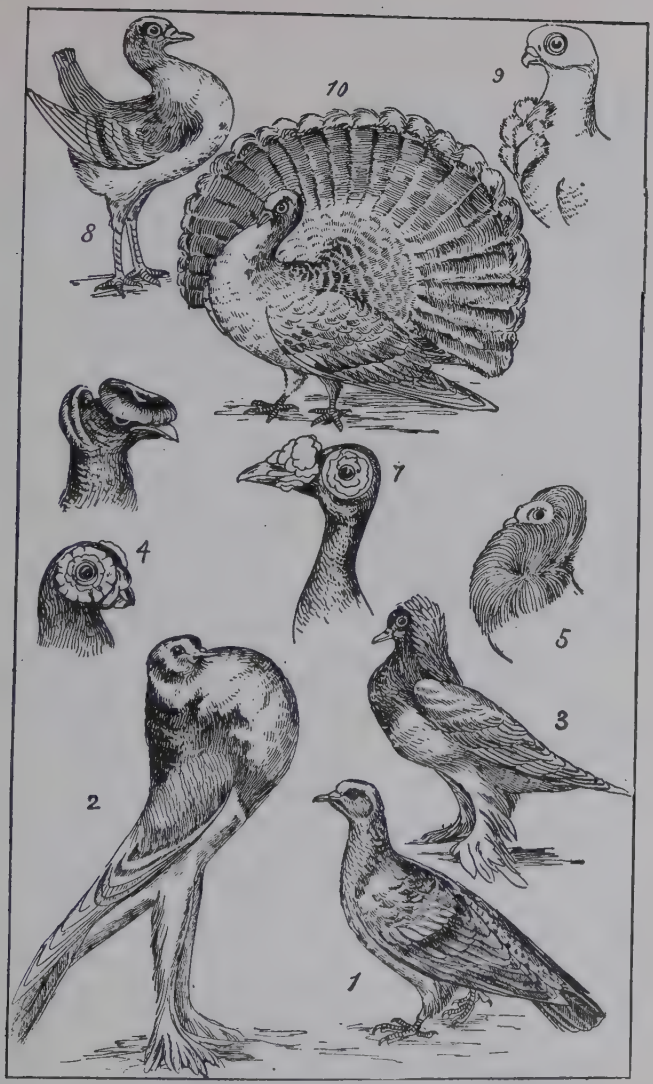

Fig. 19. Some of the many widely different kinds of pigeons evolved under domestication from the wild rock pidgeon of Europe.

evolved in cultivation from a single wild species, *Brassica oleracea*. The garden tomato furnishes a striking example of the origin of widely different forms under observation. The so-called Mikado and Upright types of tomatoes are modern offshoots from the ordinary form which differ from it and from each other more widely than do the ordinary wild forms in the genus recognized as distinct species. As these two new types preserve themselves as well as any of the recognized wild species, there is no reason why they should not be accorded similar rank. The Upright came into existence suddenly, with all its characteristic features, as a so-called "sport" or, as more recently termed, "mutation." The Mikado came into being more gradually through breeding. Even the ordinary form of the tomato has become so widely different from the ancestral form of a century ago that it must be regarded as a different species by any botanist that might find the two growing wild side by side. And, also, with other cultivated plants, there are similarly striking cases in large numbers. Also in a considerable number of wild organisms, the origin of new forms through sudden changes or mutation is matter of actual record, as in the case of the Shepherd's purse, one of the pepper grasses, from which has originated a form of separate generic rank and of marked stability.

In recent years a considerable number of new kinds of plants which have proved constant generation

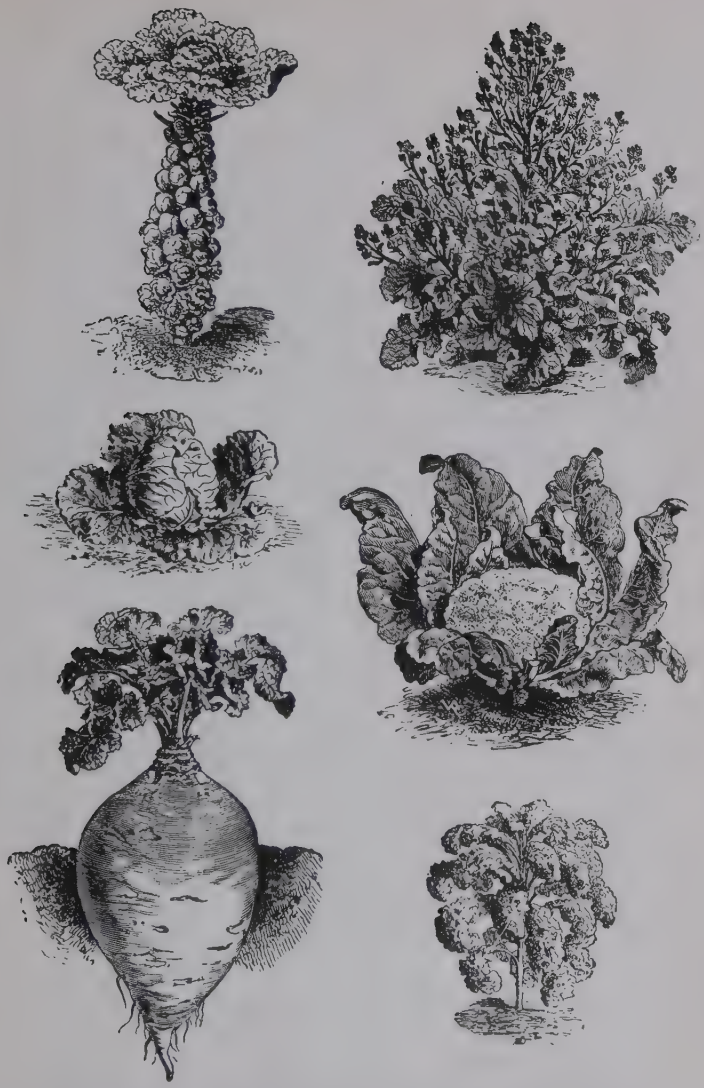

Fig. 20. Some of the many different kinds of plants developed under cultivation from a single wild species, Brassica oleracea, of Europe. At the left, proceeding from top to bottom: Brussel's sprouts (dwarf); Savoy cabbage ("early midsummer"); swedish turnip. At the right of the page, from top downward: broccoli (purple sprouting); cauliflour (early chalon); kale (tall, curled).

after generation have been obtained through the artificial induction of variations through the action of chemical solutions upon the developing germ-cells.

As Prof. L. H. Bailey says with reference to new forms of plants, we may say with reference to the new kinds of animals as well: "It is immaterial whether they are called species or varieties. They are new forms. Some of them are so distinct that they have been made the types of genera." In the same connection he says of the horticulturist that his "distinct business and profession is evolution. He, of all other men, has the experimental proof that species come and go." In the field of direct observation and experiment, then, all the evidence really required in proof of evolution is found; for the modifications produced in living animals and plants under approproiate conditions are of such profundity and show such tendency to persist, that a mere continuation of this observed evolution would in time inevitably result in a diversity wholly equivalent to that observed actually to exist in organic nature and which it is the object of the theory to explain.

CONCLUSION.

In conclusion, it may thus be said that the facts in every field of biological investigation are in the fullest accord with the theory that living organisms and their extinct predecessors on the earth have descended from

a common stock and that overwhelming evidences from all these fields converge in demonstration of its truth. There is no known fact against it. Hence, there is no longer any question or debate in the world of biological science as to whether there has or has not been an evolution; for evolution is accepted there as demonstrated in the same sense and degree as astronomers accept as demonstrated the theory that the earth and planets revolve about the sun. Both are in equal accord with known facts and processes. The physiological factors operative in controlling evolution are as yet uncertain; hence, biologists are divided into various schools representing the dominant views as to their nature, such as the Darwinians, Lamarckians, Mutationists, and so on, between which there are sharp contentions. All, however, accept evolution as a fact which is no more invalidated by their differences than would the before mentioned theory as to the movements of earth and planets be invalidated by differences in opinion as to the real nature of gravitation. As Prof. Joseph LeConte says: *"We regard the law of evolution as thoroughly established. . . . The day is past when evolution might be regarded as a school of thought. We might as well speak of a gravitationist as of an evolutionist."*

THE FUNCTION OF SCIENCE AND THE BEARING OF EVOLUTION UPON THEOLOGICAL BELIEF.

The laws of Nature occupy the position of a power with which we are not familiar, not to be arbitrarily selected and determined in our minds.—Helmholz.

Surely the reverent study of nature cannot lead men astray. These two great movements of love and of knowledge, first of the spiritual, then of the intellectual and physical ,well-being of man, will be seen to be in harmony and not a discord.—H. F. Osborn.

The dualism or antagonism manifested in what is widely spoken of as the conflict between religion and science has been a very conspicuous phenomenon in the life of recent generations. The same conflict, in one form or another, extends back to very early times; and in Greece, centuries before the foundation of Christianity, contention was rife which largely paralleled in some fundamentals the controversy of recent times. It is true, however, that a large proportion of the modern conflict has been either over non-essentials or has been due to mutual failure on the part of the contestants to understand each other. If the latter would stop long enough to agree upon definitions and to reach some real appreciation of each other's mean-

ing and point of view, they would in most cases end by agreement. It is another illustration of the dispute over the two-sided shield. Those who saw one side only might conclude the shield to be black; but the other side might, as a matter of fact, be white and those who in turn had had that side alone presented to them might justly assert the shield to be white. Both would be in possession of truth, but not of the whole truth. The full truth would consist in the combination of the partial truths possessed by the two. Both those on the side of the theologians and those on the opposing one in the controversy have been guilty of the folly of dogmatism, and in a large number of cases, as a result, the question has ceased to be as to fact or truth and has become one as to the relative skill of the opponents in debate.

Stripping off all surplusage and coming to the heart of the matter, the underlying source of the controversy with which we are dealing has always been a difference in the philosophic interpretation of Nature. From very early times there have been deep-thinking men who saw Nature as something designed and sustained by a conscious Intelligence or God; while there have been others who saw nothing in or behind Nature excepting so-called natural causes, forces acting blindly and inevitably. Either God controls Nature, or else Nature runs itself by virtue of blind resident causes. Thus we have Theism and Naturalism respectively.

The Naturalism of recent times has been essentially Materialism, embracing the view that Nature can be reduced to matter and motion. We see, then, that it is over the questions of efficient causation that contention has been especially severe and can understand why so much importance has been attached to the matter of *origins*. Now evolution deals essentially with the origin of organic forms and in the minds of many has seemed thereby to bear with great weight upon the question of causation. Hence the tremendous storm raised fifty years ago when the theory was revived with so much vigor by Spencer, Darwin and others. There were many opponents of religion who short-sightedly claimed that the establishment of the truth of evolution would be the last link in the evidence required for Naturalism; and there were not a few friends of religion who, with the utmost folly, seemed to agree that Evolution and Naturalism were one and inseparable.

It is most interesting and instructive to note that while theologians of fifty and of twenty-five years ago so widely and so warmly opposed Evolution as making for pure Materialism, most of those of the early part of the eighteenth century and, more especially, those of earlier centuries, did not look upon the variation of species or even the origin of forms spontaneously as having any theological bearing other than as "instances of that various wonder of the world which in devout

minds is food for reflection." In those earlier centuries there was never so much as a suspicion that religious faith was in any way opposed by the phenomena of the natural origination of the different forms of plants and animals. As was shown in the chapter on the history of the evolution idea, many of the ablest men of the Christian church accepted and developed a form of the theory as describing the actual, or one actual, method of creation.

It was in the latter part of the eighteenth century that the hypothesis of special creation in its rigid form first came to be regarded as an element in biblical orthodoxy. The Swedish botanist Linnæus, who himself, as a young man, had shared the prevalent belief in the transformation of species, later devised an effective method for naming species scientifically and thereafter enunciated the dogma that each existing species was separately created as such, with all its distinguishing features, in the beginning and that there were upon the earth today just as many species as had thus been independently designed and formed at the outset. There was something in the "preciseness of that age, its exaltation of law, its cold passion for a stable and measured universe, its cold denial, its cold affirmation of the power of God, a God of ice," that made the more rigid thought of Linnæus concerning living forms especially acceptable and accounts in large measure for the rapidity with which it became almost universally received

and so interwoven with the religious thought of Christianity as soon to be considered biblical, a view without rational justification. Finally, when in the middle of the nineteenth century, the old and familiar doctrine o fa transmutation of species was put forward on a scientific basis, theological belief had become so developed and set about the Linnaean dogma of a special creation, that churchmen, as before mentioned, vigorously assailed the theory in its new dress, with its indication of control through natural law and processes, as nothing short of materialism.

While the theory of descent has tnus seemed tc many to do away with creation and the necessity of a Creator altogether, the same thing has been true of various other scientific laws and teachings at the time of their first effective enunciation. As an example, the law of gravitation may be cited. This is something so different from the views that had prevailed that it seemed to "remove God from the course of Nature." There is no room for doubt that the establishment of this law was the chief ground of the widespread scepticism of the eighteenth century. The eminent sceptics, such as Voltaire, did not fail to made seemingly effective use of it in their efforts to justify themselves and to undermine faith. It was thought by many to establish the self-sufficiency of the material universe and to render untenable the prevalent view that it was sustained by God. Yet we have now so thoroughly ad-

justed ourselves to the idea of gravitation as the means of sustentation in the universe that most Christians could not think of going back to the narrower, indefinite and mysterious views of the earlier times, but feel that their religion and ground for faith have been strengthened by the new conception. That the earth is spherical, that it moves about the sun, that it is very old, that granite and related rocks were once in a molten state—these beliefs, which are now received by all as part of our common knowledge, were likewise, each in turn, once thought to militate against religion because apparently unscriptural and were accordingly opposed for a time by theologians. Christians now sense that their religion has been ennobled by adjustnent to these and other findings of science following the first perturbation and fear that the foundations of faith were being distributed.

It is clear, then, that Evolution is not alone among the teachings of science that have been looked upon, immediately following their first general promulgation, as substantiating Naturalism. Furthermore, a little clear thinking will show that the relation of the doctrine to Naturalism is precisely the same as that of any other law of Nature. It is, for example, in exactly the same position as Gravitation,—one is the equivalent of Materialism no more and no less than the other. Evolution does not add in the least to the general argument for Naturalism. It is merely the latest link in

the same chain that science from the first has been forging. From the beginning science has been revealing order and law in Nature; Evolution, in effect, only extends what had been established and universally accepted for the inorganic, in its assertion of a reign of order and law in the organic world. Thus our inquriy in its main, more fundamental phase, must be enlarged to cover science in general. What is the broader and deeper meaning of that which science has been doing and is now doing?

Science grows out of the practical necessity of anticipating and of adjusting ourselves to the environment. The power of such anticipation may be said to issue imperceptibly from the first reactions manifest in organisms. Clearly, when one of the simplest organisms responds actively and definitely to a change without it, i e., to a stimluus, with the result, it may be, that it avoids danger, or, on the other hand, secures food or other good, there is implied a fixed order or system of occurences in the environment. Were it not for this order in Nature, for the fact that the circumstance acting as the stimulus on the organism is always followed by other definite circumstances or circumstances to which the reaction or response effects adjustment, life as we know it could not exist. In a higher stage of development, the same power of meeting the environment by anticipation, an anticipation necessarily implying, as before, a fixed system in the

environment, is manifested in organic habits and instincts.

When primitive man through trial and experience acquired a knowledge of the relations of phenomena subsisting in some part of his world, he gained a certain power in dealing with that particular field, since he, out of his experience, was able to tell beforehand how events were likely to come along and thus to be prepared for them. Such tested knowledge as that giving him this skill represented science in its unconscious beginnings. The most primitive man had thus already learned to anticipate a large number of natural occurrences in their orderly sequence in his every-day life. He was, for instance, "inwardly prepared" for the alternation of day and night and the periods of the seasons. Out of such practical necessity of foreknowing the changes in the surrounding world science has developed step by step; and the methods of science are consequently in essence the methods of "common sense." Science proper began when men first consciously sought by observation and experiment exhaustively to determine the order and system in some particular field without primary reference to immediate utility. The knowledge gained by those who have made a vocation of its pursuit has been passed on from generation to generation, representing at each point of time, in place of the earlier individual skill, a "cumulative racial proficiency," available for any person

to apply to the special needs and purposes of his own life.

Foreknowledge or prescience, as previously stated, is manifestly possible only where there is a fixed order or system in Nature. That such order actually exists in every part of the known universe all the experience of the race has shown with ever-increasing emphasis. Everything in the universe happens in its own way and in no other. Everywhere we perceive constant change and alternation going on; but in this change things and phenomena come about always in a definite way, in an invariable order. Whatever we may think about the nature of the things themselves, there can be no question about their fixed succession and co-ordination. This succession and co-ordination exists wholly independently of our pleasures and wills and can be found out only through experience and trial. No matter what we may think of them, phenomena in Nature continue on in their set ways. If we are in doubt as to the conduct of light under certain conditions, proper physical experiment removes it; if we wish to know the order in which the organs appear in the developing embryo of the chicken, we look and learn. The facts are there and no power on earth can make them other than they are. No amount of debate and metaphysical experiment removes it; if we wish to know When it was first announced that there were spots on the sun, the fact was denied and opposed on the ground

that it was "impossible that the eye of the universe should have opthalmia;" but the spots remain, nevertheless. Likewise that the earth moves was vigorously opposed and many texts and authorities were cited to disprove the truth and fitness of the notion; yet the earth has gone right on moving.

An ascertained or necessary sequence of events is termed a natural law. It is seen that a law of Nature is never broken. "God's errands never fail." Upon thought, it would seem likely that the failure of any such law would mean the failure of the universe. "If God should wink at a single act of injustice, the universe would shrivel up like a cast-off snake's skin" (Arab proverb). Through the establishment of the reign of order, science has ruled out chance and has shown that the fall of the leaf is as much a matter of law as the fall of a meteor or the rushing of the comet in its path.

Science, then, seeks to determine the uniformities of coexistence and sequence in the endlessly complex world about us. It brings like by the side of like and seeks to abstract what is common in the actual diversity, giving us systems and finally laws under which the numerous separate phenomena may be ranged as instances. Its purpose is that of accurately describing phenomena in their mutual relationships. Since science makes us acquainted with things that come about in

spite of our wills, as above shown, but to which with proper foreknowledge we may accommodate ourselves, the personal qualitative elements must be eliminated from its descriptions if it is properly to serve its end. Hence, things must be described in terms of each other by means of arbitrary units; and the method of science becomes quantitative. The systems and laws of science must be rigidly accurate if reliable deductions and interpretations are to be made from them under the varying conditions of personal experience; and so science, with development, tends to take on a more and more abstract and a more and more mathematical form. Its end is an exact account of the workings of Nature, a perfect description of the order in events lying within the world of human experience.

Such a knowledge of the order in Nature as science has already given us has been of incalculable practical value to us in the conduct of our lives. It is the great source of our growing power over Nature and the basis of our material civilization. Knowing the necessary sequence of events as determined by actual experience and trial in a given field, we can secure a desired result by arranging its antecedent, or can avoid an evil by removing the conditions likewise known to lead to it. Ability in accommodation under the varied emergencies of life and especially in conscious construction toward definite ideals and ends increases continually with the growth of this proficiency

in anticipating experience. In illustration of what has been accomplished in this way for the race, the practical work in the field of sanitation, medicine and surgery, through which untold suffering and millions of lives are annually saved, need but be mentioned to be appreciated. Great though the power is that we have already secured over the forces of Nature, it is probably only the merest hint of what may be attained in the future through the continued beneficent work of science. No man can safely put a limit to the growth of practical wisdom and power.

But the work of science is clearly limited to the accurate registration and description of phenomena in their spatial and temporal relations primarily. Science properly aims at nothing beyond perfect description and formulation of natural processes. To give a reason or to state a "cause" of a phenomenon in science means nothing more than to describe the conditions under which it arises, to name its antecedents. If the mind enquires, as it sooner or later must, what the meaning of natural processes is and why things should actually come about just as they do, what the primary and real cause underlying the appearance is, science is silent. It is continually adding to our knowledge of how things in the world come about; it has never told us, and, in the very nature of things, never can tell us "why." An eternal mystery remains. To explain a thing in science commonly means simply to refer it to

its kind,—to classify it. We "explain" the movement of the earth in its orbit, the floating of a ship, the rising of a balloon, etc., by reference to gravitation, by which name we designate the kind in this case. But after doing so, we are in no manner or degree the wiser as to the real nature of gravitation,—that is as obscure as ever. Likewise we have learned much about the modes of action of light, heat, and electricity under different conditions and have expressed these in accurately formulated laws; but as to the real nature of these forces in themselves we know nothing.

Science constantly seeks aid in the description of phenomena through the employment of hypotheses in the terms of which the description may be accurately made and upon which calculations may conveniently be based. Such hypotheses are often in a high degree metaphysical; but so long as we keep in mind their real function they may be most useful. Such instrumental hypotheses have frequently to be altered with the progress of knowledge. Thus, Newton was able to explain the laws of light known to him on the assumption that light consisted of minute material particles streaming out from the luminous source; when, however, more was known about the conduct of light, it was found that some features could not be explained in terms of this "corpuscular theory." It was, accordingly, replaced by a rival theory that light was due to wave movements or vibrations in a hypothetical, subtle, imponderable me-

dium continuously filling all space and termed the "ether." This "vibration theory" has enabled us very perfectly to describe most features in the behavior of light; but now, likewise, it has proved unable to meet all requirements and, hence, in turn, it has been quietly discarded by leading scientists, although still retained for convenience of description in most text-books.

An evil frequently noted in connection with hypotheses of this kind is the tendency on the part of many people, scientists themselves as well as others, to take these essentially intrumental hypotheses as expressing or stating a concrete reality. In the case of the ether just mentioned, for example, there are many who think of an actual medium of definite qualities filling all space. To them the ether is an ultimate reality. What science properly does, as a matter of fact, is merely to describe the conduct of light as determined by experiment in terms of wave-movements in an elastic medium assumed with suitable qualities for the purpose. It has been suggested that such waves exist in the sense in which linear feet exist between the sun and the earth when we state the distance in terms of feet; and that to imagine an actual ether in the one case is much the same as in the other "to imagine the heavens filled with foot-rules and tape-measures." Yet it may, nevertheless, be advantageous to use such hypothetical waves in description in some

cases even though we know certainly that there are others in which they cannot be applied. Another example in point is the assumption of material atoms as constituting in an ultimate sense all bodies and as having their definite chemical qualities and properties of weight, volume, etc. This hypothesis has served admirably as an aid in harmonizing certain general facts in chemical processes, since formulas devised through its aid have proved uniformly true of certain aspects of these processes. But to assume that atoms are actual material, particles, inert and discrete, is quite as unwarranted at present as the assumption of an actual ether. Truly the aids of one generation become the stumbling blocks of the next; and scientists have not been free from the tendency so often charged to theologians of making what was at first purely an aid and a symbol an end and an object in itself.

This leads us more directly to consider the materialistic or mechanical conception of the universe as these terms are employed in science. As the endeavor of science is so to describe the set workings of Nature as to make possible the foretelling or prediction of phenomena, science tends always to pay primary attention to these aspects of reality that relate especially to occurrence in space and time; for a predictable event to us is determined when accurately located in time and in space. For us there can be no verification excepting through such terms. To the union of these

spatial and temporal relations in scientific description the conceptions of matter and motion have lent themselves with a particularly high degree of success. Hence, science has been formulating its descriptions in terms of these concepts almost exclusively; i. e., in mechanical terms. Science has here manifestly selected or abstracted because of this special interest and has left out of consideration various phases of reality not serving this interest immediately. Because of this abstract or partial character, science cannot logically affirm all reality to consist of matter, however supplemented, characterized by motion. All knowledge cannot be embraced in natural science on its present basis. Yet this necessary truth has not been clear to most scientists themselves. The majority of educated men have assumed, many still assume, without question, that everything can be reduced ultimately to atoms, either ponderable, or ethereal and imponderable, and motion; that the universe would be completely explained when described in these terms. But, upon analysis, these concepts are seen to be the final result of a long process of logical abstraction. Atoms are so abstract as to be even metaphysical. When, now, this atomistic framework of thought is made the concrete and ultimate reality of the universe and the thinker seeks to explain all reality, even mind itself, in its terms, he has become the slave of his own abstractions, much as though he should seek to explain

intelligence as the result of the language which it uses and which it itself has produced.

It would seem inevitable, then, that scientific materialism must sooner or later break down of its own weight. This, as a matter of fact, has already proved emphatically the outcome. It was foreseen many years ago by the famous physiologist DuBois Reymond who asserted that, working upon this basis, even in the indefinite future, we shall be ignorant of much and fail in solving Nature,—*"ignorabimus."* That the failure of the principle is now recognized by leading minds in science, may be indicated by the following sentences from an address by the eminent German chemict Ostwald: "When the attempt has been made to account for all the facts in any given field by means of a mechanical conception, it has always and without exception come to pass that an irreconcilable contradiction appeared at some point, between the actual state of the phenomena and that which the mechanical conceptions would lead us to expect." "It thus appears to result certainly from these considerations that we shall have finally to renounce the hope of explaining the physical world intuitively by tracing back its phenomena to a mechanics of atoms. But, I hear it said, if the conception of moving atoms is taken away from us, what means is left of formulating a picture of the reality? To such a question I might reply, 'Thou shalt not make unto thee any graven image or any like-

ness.'" "The life of the undulatory theory of light has been a limited one. It was carried down by its mechanical constituents. The hypothetical ether, on which the task of undulating was imposed, had to do this under peculiarly hard conditions, for the phenomena of polarization demanded peremptorily that the undulations should be transverse; but such undulations demand a rigid body, and Lord Kelvin's calculations have shown, as a final result, that a medium with such properties as this ether must have is not stable; whence the conclusion is inevitable, that it can have no physical existence." "It seems a vain undertaking, with ultimate failure decreed, to every earnest effort, to interpret known physical phenomena mechanically; hence the conclusion is unavoidable that the attempt can still less succeed in the vastly more complicated phenomena of organic life. The same contradiction of principle forces itself upon us here, and the supposition that all natural phenomena can be traced back to mechanical factors cannot even be designated an available working hypothesis. It is a mere error." "Science again has free course."

To summarize, then, we may say that the goal of science is the complete and perfectly accurate description of the coincidences and sequences of events in the phenomenal world. Science has grown out of the practical necessity of anticipating changes in the environment; and, hence, the tendency is for it to use in

the descriptive construction of its systems only such conceptions as serve this end, these being primarily temporal and spatial. Its interest being thus selective, science becomes in its nature abstract. Scientific knowledge, therefore is partial. Natural science proper cannot embrace all knowledge; and its terms are not final or in any way exhaustive of reality. Should it succeed in any field in completing its work, there would still remain a large amount of reality in that field unexplained and untouched. Science serves its purpose in giving us a verifiable description of the workings of Nature. It gives us no hint as to underlying causes and does not interpret to us the meaning of the processes it describes. We must regard scientific concepts as true in so far as they describe tested facts or processes of Nature, but no father. When men attempt to supplement the proper findings of science in such a way as to make entities of or behind the processes actually tested, as instance the laws of light and the hypothetical ether, only confusion and error can result and we may wisely refuse her lead. Science in her proper field, in her constant growth and progressive rectifications, however, is supreme. Her formulations represent the quintessence of the accumulated practical wisdom of the race and form the basis of our material civilization.

Since, then, the view that the superficial procession of phenomena with which science deals is ex-

haustive of reality is untenable, as the leading minds among the scientists themselves are coming to recognize, the argument from the materialistic basis so far fails wholly. Scientific description, however perfect it may be, and beyond estimate though its value is, does not reveal the activating ground of phenomena. It supplies us with no real cause. For purpose of descriptive record scientists have pulverized Nature; but they now find the dust "inadequate to produce the Universe."

Reverting again to the doctrine of Evolution, we see that though science should succeed in thoroughly establishing the order of the appearance of life forms through their lineages back to the earliest common stock, though every phase and detail of the process should be laid bare, it could say no word as to the cause any more than it can in the case of any other natural occurrence, be that what it may. We should know the historical facts with the utmost clearness—the ultimate cause and meaning would remain untouched and as impenetrable as before. Evolution leaves the theistic argument from causality in its essence untouched and as before. It does not evidence as in any way illusory the belief that the "soul of truth lies in the recognition that the world which is immediately revealed to us in sense perception, and the processes of which are recorded in science, has a deeper ground than this material appearance * *

a ground which reflective analysis obliges us to hold as spiritual" (J. G. Schurman).

Evolution is not a negation of creation, though it refutes a particular theory of creation that has enjoyed long and wide credence. Few will deny that there must have been some way or mode in which the Creator worked or assert that creation was or is without process. Evolution is a description of the manner of creation. It answers in a measure the question "How;" but leaves untouched the question "by what or by Whom?" The explanation of phenomena which Evolution unlocks, after the manner of all scientific explanation, remains essentially on the surface and leaves the real power at work in no way discovered.

The situation may, perhaps, be made plain by reference to the origin of the individual. As is well known each one of the higher animals takes its beginning in an extremely simple and minute germ, which in visible features much resembles one of the lowest "one-celled" organisms in its normal adult state. From such a simple particle of organized substance growth and gradual complication lead through a remarkable series of changes to the orderly formation and perfecting of organs and systems until the individual body is fully endowed. Such development is sometimes spoken of as one form of evolution in the broad sense, and serves well as a type of the general process. Through evolution from the simple cell

of living substance (or protoplasm), then, each individual organism has been formed. But, because we have found out how the individual takes form and comes into being, Christians do not on that account deny God as the Creator of individuals. Why, then, when it is merely asserted that the method of formation of living individuals in all times past has been the same as that we see operative at present, should some people see in the view a denial of a Creator? Why the different interpretation in the two cases? Evolution simply teaches that the method of creation of individuals has been uniform from the first; and that from generation to generation and from age to age through the orderly accumulation of such individual differences and variations as we see in the living world now, there has resulted such development and modification as to account for all the existing diversity and multiplicity. The gradual complication in the living world as a whole is strictly comparable to that observed in following through the progressive stages in the development of each individual from its germ. Creation thus becomes one grand process instead of an infinite number of separate acts and to the Christian "a continuous revelation of God." And, just as many no longer see in Gravitation any proof of Materialism but through it find their faith rather ennobled, so there

appears nothing against the view that Evolution is the Divine method of creation.

Of all the evidences that have been advanced to prove the existence of a God, none has seemed in the past to have had greater weight in the minds of thinking men than that based upon evidence of the presence of design in Nature. To Kant, this theistic argument seemed the clearest of all. His statement of the argument has been thus summarized: "First, there are in the world clear indications of intentional arrangements, various and boundless. Secondly, these could not have originated spontaneously from the nature of things themselves, but only through means selected and arranged on purpose by a rational disposing principle, according to certain fundamental ideas. Thirdly, there exists, therefore, a free, intelligent cause of the world. Fourthly, the unity of this cause may be inferred from the unity of the reciprocal relations of the parts of the world."

There is but one way open for the teleologist to judge of the existence of purpose or ends in Nature, and that is to make comparisons between what he finds in Nature and the positive activity of his own mind "That there is design in Nature nothing but the discovery of analogies to the intellectual purpose of man can make even probable." The thinkers of the eighteenth century satisfied themselves, in particular, of the existence of design in the animal world. They

did not hesitate to enumerate in special treatises on Natural Theology numerous examples of arrangements for supposed specific ends which seemed clearly to demand a Designer. That was a mechanical age and men were prone to account for the whole procession of phenomena in the inorganic world as resulting purely from the self-operation of blind forces resident in matter. The inorganic world to them largely accounted for itself. But animals were beyond their comprehension as anything other than marvelously wrought machines immediately contrived by an extraneous Worker and in their constructions and activities showing to them specific purposes of that Worker. This is, apparently, the view of the generality of people today.

There is no denying the fact that it is now much more difficult to find substantial ground in the particular arguments of the design-naturalists than it was in their day. The tremendous progress in biological science in general, has served to remove from living organisms much of the unique inexplicableness they once had and has shown that it is possible to account for a large percentage of what were formerly regarded as directly designed and expressed features through the operation of natural laws. To such minds as received without question the mechanical view of the inorganic world living things have thus seemed to pass into the same realm. True, the organic world has

most clearly passed under the reign of universal law; but the interpretation of the meaning of this by a transfer of the eighteenth-century mechanical conception has no legitimacy in view of the present complete discredit of this principle. The progress of knowledge makes it imperative that the teleologist take a higher and broader ground; and in his doing so he confesses to find his position not weakened, but strengthened.

Very frequently it has happened that what have been selected as the specific purposes of organs or contrivances have, with better knowledge, proved not to be the real ends. It is hazardous to assume that the most salient feature or function in things is their essential end. As President Schurman suggests, "That the property of rain is to wet, and fire to burn," is of interest only in the natural philosophy of Touchstone. We live in a closed universe and are in a position, little favored to open to us, through our direct efforts, the purposes of its Creator. Our likelihood to err may be brought out by adapting here Huxley's parable of the clock and the death-watch. Imagine a clock which ticks, shows the hours, minutes and seconds, the days of the week and month, the phases of the moon, cries "cuckoo" and does perhaps other things. Suppose, further, that inside the clock abides a watch capable of study and reflection. After an exhaustive study of the works of the clock, the watch might exclaim, "I

find here nothing but mechanism throughout; at any instant I can tell all of the changes that are going on together, those that have preceded and those that are to follow." But if it concluded that, therefore, the clock had no designer, showed no purpose and wound itself up, the error would be profound. Again, the watch might consider that purpose certainly exists in the clock and might seek to ascertain what that purpose is. After study and meditation it might show with much clearness that the one thing the clock was always doing was to tick, and might point out with the utmost clearness how perfectly the pendulum and other features in the mechanism of the clock contributed to the fulfillment of this function. But if the conclusion were drawn that the purpose of the clock was to tick, it would be absurd, inevitable though it might seem to the watch. The real purpose would be forever beyond the comprehension of the watch thus shut up in its closed world.

From the wider outlook which the increasing experience of the race has now made possible, it becomes clear that evolution does not negate design in Nature although it refutes a particular theory. To many the argument from design seems never to have been of great consequence, Design can be neither affirmed nor denied at this time from the study of isolated or particular facts in biology like those to which Paley gave weight. We must come to contemplate Nature

in its broader aspects, in its unity and order as a whole, and to see that purpose must be looked for as expressed through natural laws,—not outside them. The theistic teleology based upon the contemplation of the unity, order and harmony of the whole universe is acknowledged to be far more forceful and far grander than the outgrown theory it has displaced; and the faith rooted in the deep admiration its appreciation has in many inspired, seems certainly nobler and more secure than that growing out of mere wonder at the particular contrivances sought out by the design-naturalists.

It was a principle recognized by Aristotle that the result of a process must interpret its beginnings. To condemn a thing or system as unworthy or imperfect because of a simple and seemingly low origin is not to be justified. The tree is known by its fruit. But, after all, what is the simplicity out of which the complexity and heterogeneity of the world has seemed to be evolving if we interpret things according to mechanical principles? Perfected mechanical processes work backwards as well as forwards. Hence, mechanically interpreted, the actual Nature we know, one of extreme complexity arranged in order and unity as the Cosmos, as the outgrowth of that of yesterday must have been contained in the latter in some way. And so, tracing things back from effect to cause to a beginning ever so seemingly simple and homogenous,

we must suppose them to have been contained there fully and completely. Because of the logical equivalence of cause and effect, we must suppose the complex cosmos actually to have been involved in that beginning. To say that it was there potentially does not alter the fact that it was there in a real way. The essential complexity cannot have increased. It was of necessity at each point in past time a highly organized and complex whole. The simplifications we make in abstract analysis cannot upon this basis be true for the actuality; and upon this basis, as a result, it would seem impossible to look upon evolution as valid in causation. If everything in existing Nature has been derived according to natural law from a primordial arrangement of things at what may be considered the outset, there can be no question that the terms and any purpose or end apparent in the issue must already, in some form, have been present in the beginning. The entire outcome in the organic world must have been fully prefigured or conditioned in the lowest primordial germs or organisms and the environments, else from these it never could have evolved into actuality, much as the individual exists potentially in the egg-cell. Any mechanism or processes that may be found to constitute factors in the unfolding may by the theist be logically regarded as the preordained means for the realization of a Divine purpose present from the "first."

Evolution, far from disproving purpose in Na-

ture, rather affirms it, as Paley himself sensed; for, in an anticipation which few of the host of his admirers in past generations recognized, he virtually accepted the doctrine. Separate acts interposed in a discontinuous manner would apparently result in a meaningless creation; but orderly development or evolution in its very nature involves a passage through serial changes that lead in a determinate direction and toward a definite end. The perception of a comprehensible plan in Nature as supplied in Evolution to many minds proves, and to others presents good evidence of, the existence of an Intelligence back of Nature to which our own has kinship. The occurrence in Nature of imperfect adaptations and partial failures, of a reaching out or trying at many points, in strongly suggesting a tentativeness analogous to that characterizing our own conscious and purposeful efforts, instead of being the stumbling block so many have openly feared, to others, upon reflection, becomes strong additional evidence in support of the same view.